





RATIONAL RECREATIONS,

In which the PRINCIPLES of

N U M B E R S

A N D

NATURAL PHILOSOPHY

Are clearly and copiously elucidated,

BY A SERIES OF

EASY, ENTERTAINING, INTERESTING
E X P E R I M E N T S.

Among which are

All those commonly performed with the CARDS.

By W. H O O P E R, M. D.

V O L. IV.

THE THIRD EDITION, CORRECTED.

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RATIONAL
RECREATIONS.

VOLUME THE FOURTH.

CONTAINING
EXPERIMENTS
IN
PNEUMATICS, HYDROLOGY,
AND
PYROTECHNICS.
WITH AN
APPENDIX.

OF
MISCELLANEOUS RECREATIONS.

DESCRIPTION of the PLATES.

PLATE I. p. 8.

THE common air pump. *A A*, are two brass barrels ; *C C*, two pistons, working in those barrels ; *B* the handle by which they are worked ; *G G*, the pillars that support the frame of the pump wheel, screwed on them by the nuts *F F* ; *H H* is a brass pipe called the swan's neck, through which the air passes, from under the receiver *O O*, by a small hole *K*, in the middle of the brass plate *I*, to a brass piece in the box *D D*, from whence it is pumped out. *LLL* is a mercurial gage, that communicates with the receiver ; *N* the stop-cock, by which the air is re-admitted, when necessary.

PLATE II. p. 16.

Fig. 1. The animometer. *ABCDEFGH* is a frame of wood, supported by the post *P* ; *Q M* a horizontal axis, that moves in the cross pieces *I* and *L*, by means of the four fails *a, b, c, d, e, f, g, h* ; on this axis is fixed a cone of wood, *MNO*, by which the weight *S* is raised :

A 3

IK

IK is a ratchet wheel, whose teeth are taken by the click X.

Fig. 2. The circular hygrometer. ABCD is a square board ; at the point E a catgut is fixed, that passing over several pullies, marked C, is fastened at the other end to the spring F, which is regulated by the screw I. At H a brass indented ruler takes the teeth of a pinion K, whose axis goes through the board, and on the other side carries the index A that points to the divisions of the circle E.

Fig. 3 and 4. The perpendicular hygrometer. The circles marked C are pullies, over which passes a string, that is fastened at A, and the other end has a weight F. A piece of brass is fixed to the string at G, and moves freely in the groove HI; to this brass piece, on the other side of the board is fastened an index E, Fig. 4, which shows the degree of moisture, by the scale LM.

Fig. 5. RS a catgut that is fastened at S, passes over the pulley T, and has a weight at V, to the top of which is fastened an index that points to the scale Z.

P L A T E III. p. 46.

Fig. 1. The air gun. ECDR the outer barrel ; KA the inner barrel ; SMNP the syringe, by which the air is injected through the valve NP ; TL another valve, that is opened by the trigger O, by which the air enters behind the ball at K, and drives it out.

Fig. 2. The lock of this gun.

Fig.

Fig. 3. The machine for artificial rain and hail. A, A, &c. the boards that have holes through which shot passes. D the axis on which the wheel turns.

Fig. 4. The magical tree. A B C D the box that contains the copper vessel F G, into which air is forced by the syringe M N, Fig. 5. At I is a cock, that lets the air into the hollow stalk of the tree O, and from thence it passes, by the other branches, which are hollow likewise, to the fruit and flowers.

P L A T E IV. p. 64.

Fig. 1. C A D B a vessel of water, in which one end of the syphon F is plunged, and being exhausted of the air, the water runs out at the other end E.

Fig. 2. A sucking pump. C D the piston, E F two valves that open upward, M N the water in the well, H the pipe by which it runs out.

Fig. 3. The forcing pump. C a solid piston, D a valve, H the pipe for conveying the water, in which is the valve E, through which the water is forced, by the piston C, into the cistern F, from whence it runs out.

Fig. 4. The lifting pump. B D is an inverted piston placed in the frame G E Q H O; when this part is pushed down the water ascends through the piston D, and when the frame is drawn up, it is forced through the valve C, and out of the cistern at H.

P L A T E V. p. 78.

Fig. 1. The simple hydrometer. *B b* a copper ball, in which is fixed the brass wire *AB*; on this wire are several marks which show the different gravities of fluids, as in Fig. 2.

Fig. 3. The compound hydrometer. *B* is a hollow ball, to which is screwed another ball *b*, filled with mercury. In the ball *B* is fixed a graduated wire *AC*. *A* is a small weight that makes the wire descend the different depths, according to the gravity of the liquors.

Fig. 4. The hydrostatic balance. From the point *A* is suspended the bar *B B*, to which hangs the balance *b*, that is checked by the spring *z y*, supported by the piece *M*. From the bottom of each scale *e* and *d*, hangs a wire, that goes through the table; and to that from the scale *e*, is fixed another graduated wire *rs*, at the bottom of which is a weight *L*, and to that hangs a wire with a small brass ball *g*. *T* is an index, placed against the graduated wire *rs*. At the end of the wire that comes from the scale *d* hangs, by a horse-hair, a glass tube *R*. The string that goes over the point *A* passes down to the bottom of the stand, and is fastened to the screw *P*, by which the balance is raised or lowered.

P L A T E VI. p. 84.

Fig. 1. The screw of Archimedes. *AB* a cylinder, round which runs a pipe *CD*, whose lower
end

end is immerfed in the water ; D is the end of the pipe from whence the water iffues ; K the handle, fupported by the piece I R.

Fig. 2. The hydraulic fcoop. B the fcoop, A the point from which the handle C is fufpended.

Fig. 3. The balance pumps. A B the balance, O, P, the pumps ; M, N, the piftons ; H H the pipe through which the water is conveyed ; F, G, are two fprings to return the balance.

Fig. 4, fhows the manner in which the balance moves on the points C.

Fig. 5. The hydroftatic bellows. A B and E F two circular boards ; A E and B F the fides, which are of leather ; D C a pipe fcrewed into the board.

P L A T E VII. p. 92.

Fig. 1. The water-cock. A B C D a glafs veffel, E a fmall glafs tube glued in the veffel ; G I another glafs tube, to which hangs a weight L ; F the cover of the veffel.

Fig. 2. The hydraulic dancer. A B a figure made of cork ; C a hollow cone placed under the figure,

Fig. 3. A hollow ball of copper placed on the top of a fountain.

Fig. 4. The globular fountain. A is a hollow globe of copper, fixed on the pipe B, whose orifice C is placed over a jet.

Fig. 5. The hemifpherical cascade. In a hollow inverted cone A, is fixed a pipe B, and the
water

water that falls from it runs over the side of the cone C, in form of a hemisphere.

Fig. 6. The same piece reversed, when it forms a fountain in the figure of a vase.

Fig. 7. The water-fun. A is a hollow vessel in the middle of which are a number of holes, and the water that comes from the jet, on which it is placed, rushing through those holes, forms the resemblance of a fun, as in the adjoining figure.

Fig. 8. Several pieces, of the same sort with the last, placed over each other, in a horizontal direction, and all supplied by the same pipe.

P L A T E VIII. p. 108.

Fig. 1. The revolving water-fun. A hollow circle, in which there are several holes, is fixed on the top of a jet, and as the circle turns round the water rushes out of the holes.

Fig. 2. The magic bottle. A B a bottle filled with wine ; C D a vessel filled with water to the top of the bottle.

Fig. 3. The marvellous vessel ; B the mouth of the vessel, which is filled with water and stopped, and at the bottom A are several holes.

Fig. 4. The magical cascade. AB a tin vessel that holds the water ; DE a pipe fixed to the vessel ; F, F, small tubes through which the water flows, G H the basin to receive it.

Fig. 5. The circulating fountain. E C the box that contains the water ; W A the basin in
which

which the fountain plays ; WX the leg, by which the water runs into the box DX; YZ the leg through which the air is forced into the box EC.

Fig. 6. The compressed jet d'eau. A is a copper vessel, in which is a pipe BE, and in that another, G, that is smaller ; H is a cock to let out the air.

Fig. 6. The illuminated fountain. AB and CD are two cylindrical vessels, that are connected by four tubes H, I, &c. and to each of these tubes candlesticks are fixed. At G is an aperture, by which water is poured into the vessel CD, and at K is the jet.

Fig. 8. The solar fountain. GNS is a thin hollow globe of copper. Through the leg C of the table AB passes a pipe that goes to V. At K is a cock by which the fountain is stopped.

P L A T E IX. p. 124.

Fig. 1. The cup of Tantalus. This cup is filled with water to S, and at A is placed an image that contains a syphon, which begins at one foot of the image, goes up to his breast, then down to the other foot, and out at the bottom of the vessel.

Fig. 2. The sea-gage. AB the gage bottle ; Ff the tube, the lower end of which is immersed in mercury ; GH is a pipe of brass that has several holes to admit the water into the bottle AB ; K a weight that hangs by the shank L in the socket N ; I is a large empty ball, fixed to the brass tube H.

Fig.

Fig. 3. An instrument to be added to the sea-gage, to measure great depths. BCDF a hollow metal globe, to the top of which is fixed the long tube AB: at the part D of the globe is joined a short tube DE, that is to stand in the mercury and treacle.

Fig. 4. The diving bell. A B the top of the bell: D a glass to admit the light; H a cock to let out the foul air; L M a circular seat for the divers to sit on; C one of the barrels by which the divers are provided with fresh air; F a diver dispatched at some distance from the bell.

Fig. 5. A diving bell for a single person. A B the bell sunk by weights at D; G, G, G, three glasses to admit the light, which are defended by the lids H, H, H, F F F chains that support the ring E, on which the diver stands.

P L A T E X. p. 164.

Fig. 1, and 2, are papers cut through with a piercer, and behind them a light is placed, by which they appear as illuminations.

Fig. 3, 4, 5, 6, and 8, are other papers of the same sort as the last figures, but these are to revolve on a wire wheel, as fig. 7.

Fig. 9, is an illumination where the fire appears to proceed in different directions.

Fig. 10. A double revolving wheel of fire, that at B proceeding in a different direction from that at A.

Fig. 11. The burning fountain. ABCD is a copper vessel, in which is fixed the eolipile, that has

has a cock at G, and a small pipe, F, with a very small orifice.

P L A T E XI. p. 168.

Fig. 1. A wheel for representing illuminations in various directions; A, A, &c. are pyramids that appear to turn on their centers.

Fig. 2, and 3. The apparatus for cascades of fire. Fig. 2, the manner of piercing the paper. AB, Fig. 3, is a paper rolled on a cylinder, and as it is unrolled by the handle D the cascade gradually appears.

Fig. 4. The manner of representing a cascade by a spiral.

P L A T E XII. p. 200.

Fig. 1. The machine for the luminous oracle. ABCD a tin box. At M is a door in the back of the box, where the lights are placed in it; L, the opening in front, by which the objects are viewed.

Fig. 2. OP is double glass, between which a composition is put; on the back glass a picture is painted, and on the front glass a paper, divided into 45 parts.

Fig. 3. A pasteboard divided into 15 equal parts, similar to those in the last figure.

Fig. 4. ABCD a tin box. FGHI its pedestal, in which by the door at L, a chafingdish is placed. O a glass in the front of the box; R a flower placed in a tin tube.

Fig. 5. The box for the marvellous portrait. A the cover of the box, B its bottom, CD a false bottom, that draws out.

Fig.

Fig. 6. The artificial hand. This hand is placed on a pedestal, covered with a thin stuff; at ST is an opening, and at I, a roller, by which the motion of the arm is facilitated. In the lower figure the elbow is joined to the piece F, that turns in two screws C and D; the end F goes through a partition, and by that end an assistant moves the arm.

Fig. 7. The talisman. ABC a triangular box; B a plate to be put at the bottom of the box; Q a copper triangle to be placed under the top of the box, and fastened to the knob O.

P L A T E XIII. p. 228.

Fig. 1. The box for the fybils. AB a hollow pedestal; C a box that communicates with the pedestal. In the divisions of the circle M are the names of the months, and the names of the days of the week. M is an index that turns freely on its center, and between ON is an opening into the pedestal, in which moves the bent index R. P is a pulley whose axis is directly under the center of the circle M. S and T two rollers, and at the end of T is a pulley V. X is a small pulley, round which goes a string that communicates with P and T. D an opening in the front of the box, where the name of one of the fybils appears.

Fig. 2. The magic urn. A B a hole, in which the cylinder C, Fig. 3, is to be placed. D the top of the cylinder.

Fig. 4. The box for the incomprehensible writing. DE, Fig. 5, shews the inside of the top
of

of the box ; L, a plate of copper, to be placed in the part D of the top of the box.

Fig. 6, is a slip of paper GH, of the same size with the bottom of the foregoing box; at each end of this paper is wrote the name of a card.

Fig. 7. The oracular mirror. ABCD the mirror, which is moveable in the frame, and is seen under the glasses placed in the small circles.

P L A T E XIV. p. 276.

Fig. 1, and 2, The disposition of the fingers in making the pafs.

Fig. 3, 4, and 5. The cards for the fifteen thousand livres.

Fig. 6, 7, and 8. Cards for a recreation similar to the last.

Fig. 9. The magic ring.

Fig. 10. The card in the mirror. B the part of the glass where the quicksilver is scraped off, and the card appears. CD and EF the grooves in which the mirror moves.

Fig. 11. The marvellous vase. AB the the section of the vase: *c d e f g* the divisions in which the cards are placed; H the point to which a string is fixed, that goes down the three small divisions, under the pulley I, through the bracket L, and comes out behind the partition M.



RATIONAL RECREATIONS.

P N E U M A T I C S.

DEFINITIONS.

1. **T**HE atmosphere is that body of air which every where furrounds the earth..

2. The air-pump is a machine contrived to produce a vacuum, by exhausting the air out of a vessel called a receiver.

3. The condenser is an instrument generally in form of a syringe, to force a greater quantity of air into any vessel than it naturally contains.

4. The animometer is an instrument that measures the strength of the wind.

5. The hygrometer is contrived to show the different degrees of moisture in the atmosphere at different times.

6. The thermometer measures the degrees of heat and cold of the air, and of other bodies.

7. The barometer shows the different weight of the air at different times.

A P H O R I S M S.

1. The air is an elastic, ponderating, compressible and expansible fluid, that is sensible only to the touch.

2. The elasticity of the air is increased by heat and decreased by cold *.

* This is proved by the common experiment of tying the neck of an inflated bladder, and laying it before the fire: for the heat, by expanding the small quantity of air in the bladder, will extend it to the utmost stretch, and at last burst it, with a loud report. But if after the bladder becomes distended it be carried into the cold, it will immediately resume its flaccid form.

3. The

3. The weight of the air is so small as not to be perceived but in large quantities*.

4. The rarefaction and condensation of the air, are indefinite†.

* A gallon of air weighs one dram, nearly. A column of the atmosphere, whose base is a square inch is equal to 15 lb. consequently the surface of a man's body, of six feet stature, being on an average equal to 14 square feet, it must be pressed by a weight of air equal to 28000 pounds. This great weight is counteracted by the air within the human body; which, though small in quantity, is, by its spring, sufficient to balance the external air.

† Mr. Boyle found that the air near the surface of the earth is compressed, by its own weight, into a space less than $\frac{1}{13000}$ part of the space it would take up if left at liberty: and as the common air may be compressed into $\frac{1}{60}$ of its natural space, it follows that the air may occupy a space 780,000 times greater at one time than another. Dr. Gregory has shewn, that if a globule of air of one inch diameter, had as great an expansion as it would have at the distance of a semidiameter of the earth from its surface, it would fill all the planetary regions, as far as, and even beyond the sphere of Saturn.

5. Though air is greatly condensible by cold, it cannot be congealed.

6. Air is necessary to animal existence*.

7. Aduft air, that is such as has passed through the fire or a heated tube, will not support animal life †.

8. Air is contained in almost all bodies, and may be produced from them ‡.

* This has been proved by many, far too many experiments, with the air-pump. It is not however universally true, for toads, vipers, eels, insects of every kind, and fish, live in the exhausted receiver.

† An animal put into a receiver filled with burnt air will expire immediately. Live coals and candles will likewise go out when put in such air.

‡ Air is produced from bodies by their dissolution, that is by fermentation, distillation and similar methods. The quantity of air produced from bodies is very different. Yellow wax contains one-sixteenth, coarse sugar one-tenth, oyster-shells and mustard seed one sixth, heart of oak one-fourth, pease, dry tobacco, and Newcastle coal one third, and the calculus humanus, or stone found in the human bladder, one half of their several weights.

9. Sound

9. Sound is communicated by the air *.

10. The atmosphere is of different densities at different heights, and is most dense near the earth †.

11. The height of the atmosphere does not exceed 50 miles ‡.

12. Wind is nothing but a current of air.

13. The velocity of the wind is from 1 to 60 miles in an hour §.

* This is proved by the bell in the receiver of the air-pump, as will be seen in the Recreations.

† At the height of 42 miles the air is computed to be 4096 times more rare than at the surface of the earth.

‡ As the air becomes continually more rare as its distance from the earth increases, it is impossible to determine its exact height, but by different experiments, especially by observing the duration of the twilight, it may be reckoned from 45 to 50 miles.

§ It must be a very strong wind that goes 60 miles in an hour. The velocity of the wind at a medium, may be reckoned 12 or 15 miles per hour. If a person go the same way with the wind, and with an equal or greater velocity, he will not know

THE PNEUMATIC APPARATUS.

OF all the pneumatic apparatus the air-pump is doubtless the most important, and that as well from its entertainment as the elucidation it affords to this branch of science.

The construction of the common air-pump is as follows. A A, Plate I. represent two brass barrels, in which the pistons C C act. The brass pipe H H is called the swan's neck, through which the air passes from under the receiver O O, by a small hole K in the middle of the brass plate I, on the top of the pump, to

there is any wind ; while another going against is, or with a less velocity, will perceive it very sensibly. Dr. Derham found by repeatedly observing the space passed over by a feather, with a half second watch, in the great storm in 1705, that it was 33 feet per half second, which is equal to 45 miles per hour : from whence he concluded, that the most vehement wind, as that in November 1703, does not exceed 50 or 60 miles per hour.

a brass

a brass piece in the box D D : which being perforated likewise to the middle point under each barrel, transmits the air by a bladder valve, to be pumped out.

The mercurial gage which communicates with the receiver, is marked L L L. The stop-cock N, serves to re-admit the air, when necessary. B is the handle or winch for working the pump. G G are two pillars, supporting the frame of the pump-wheel, which is screwed upon them by the two nuts, E E. The use of the other parts will readily appear from an inspection of the figure.

The operation of this machine depends on the elasticity of the air ; for as the piston rises, the air in the receiver by its spring is forced into the barrel of the pump, through the valve at the bottom, which valve prevents its return into the receiver ; the piston in its descent, then compresses the air in the barrel, by which

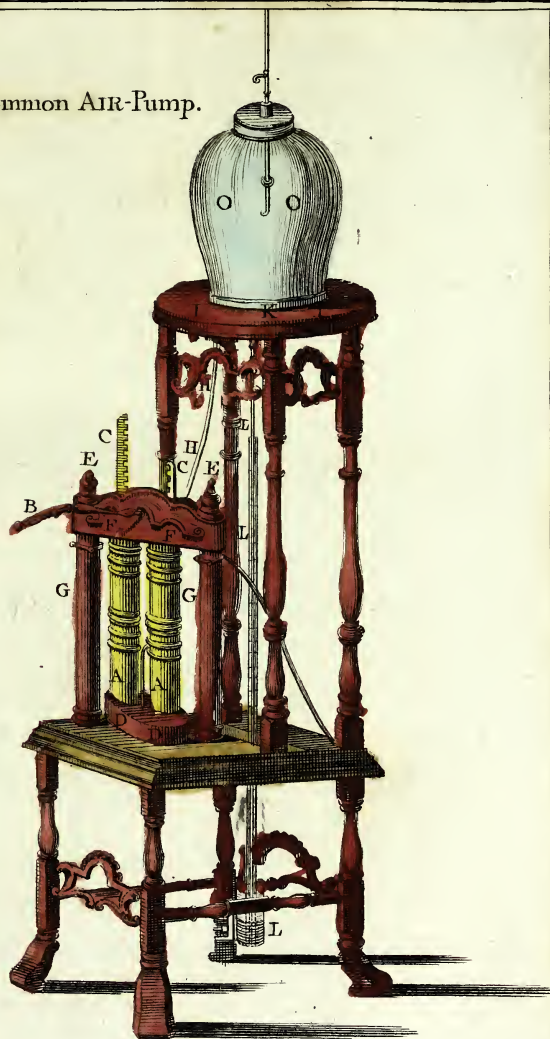
B 4 means

means it is forced out through the valve in the piston, into the external air. By continually working the pump, the pistons act alternately and the receiver is gradually exhausted ; but the air can never be totally drawn out, so as to leave a perfect vacuum ; for it must be remembered, that the air is forced into the barrels by the spring of that which remains in the receiver ; therefore to exhaust every particle, the last must be expelled without an agent, which is absurd.

Such is the construction of the common air-pump ; but there is another, invented by Mr. Smeaton, by which a purer vacuum is obtained, and which also acts as a condensing engine. There is moreover, what they call a portable air-pump, which is placed on a table, and may be easily conveyed from one place to another.

T H E

Common AIR-Pump.



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THE ANIMOMETER.

THE construction of this instrument may be as follows. Let A B C D E F G H, (Plate II. Fig. 1.) be an open frame of wood, firmly supported by the post P. In the cross pieces I and L is moved an horizontal axis Q M, by means of the four sails, *a b*, *c d*, *e f*, *g h*, exposed to the wind in a proper direction. Upon this axis is fixed a cone of wood MNO, upon which as the sails move round, a weight S is raised, by a string on its surface, proceeding from the small to the largest end NO. Upon the great end or base of the cone, is fixed a ratchet-wheel I K, in whose teeth falls the click X, to prevent a retrograde motion from the depending wheel.

It is easy to perceive, from the construction of this machine, that it is adapted to estimate the variable force of the wind, because

because the force of the weight will continually increase as the string advances on the conical surface, be acting at a greater distance from the axis; and therefore if such a weight be put on the smallest part at M, as will just keep the machine in equilibrio with the weakest wind; as the wind becomes stronger the weight will be raised in proportion, from S towards R; and the diameter of the base of the cone N O, may be so large, in comparison of that of the smaller end or axis at M, that the strongest wind shall but just raise the weight to the great end.

Let the diameter of the axis, for example, be to that of the base of the cone N O, as 1 to 28. Then if S be a weight of one pound on the axis at M, it will be equivalent to 28 pounds, or one-fourth of a hundred weight, when raised to the greatest end. Therefore, if when the wind is weakest it support one pound on the axis, it must be 28 times as strong to raise the weight

weight to the base of the cone. It follows, that if a line of 28 equal parts be drawn on the side of the cone, the strength of the wind will be expressed by the number on which the string shall at any time hang.

This string may, moreover, be of such a size, and the cone of such a length, that there may be 16 revolutions of the string between each division of the scale on the cone ; by which mean the strength of the wind will be expressed in pounds and ounces. If still greater accuracy be required, let the periphery of the cone's base be divided into 16 equal parts : then, wherever the equilibrium happens, the string will leave the conic surface against one of those divisions, and consequently show the force of the wind to a dram averdupoise weight.

T H E

THE CIRCULAR HYGROMETER.

TAKE a board ABCD, about a foot square (Plate II. Fig. 2.) and bind it round either with four pieces of iron, or dry hard wood, about half an inch thick, to prevent it from enlarging, to any sensible degree, by the moisture of the air. At the several parts marked C, in the figure, place pullies of about half an inch diameter, and that turn quite free on their axis. At E fix one end of a catgut, of the size of the smallest string of a violin; let it pass over all the pullies and be fixed, by the other end to the spring F, which is to be adjusted by the screw I, so as to have more or less force.

Near the center of the board is to be fixed to the catgut a brass ruler H, about an inch long, and that has 20 or 25 teeth, which are to take those of the pinion K, whose axis, which is in the center of the board, passes through it, and stands out
on

on the other side, on which is to be fixed a very slight index, (see Fig.) and round the center describe the circle E. Cover that side of the board on which are the pullies, with a cloth.

As the moisture of the air will contract the catgut, which is near six feet long, and the dryness extends it; by means of the spring the brass ruler will ascend in the first state, and descend in the other, and by its motion will necessarily turn the pinion and index.

To regulate this hygrometer, the circle E being divided into 60 equal parts, as in the figure, choose a time when the air is very dry, and fix the index against the first degree, and as the air becomes moist the index will show, by the number of divisions it passes over, the degree of that moisture. If the index should be found to make more than a complete revolution, the spring to which the catgut is fastened, must be contracted.

THE

THE PERPENDICULAR HYGROMETER.

ON the board A B C D, that is a foot long and three inches wide, (Plate II. Fig. 3.) let a catgut pass over the eight small pullies marked C, and be fixed at one end to the top of the board, and at the other to the weight F. To the catgut fasten a small piece of brass at G, which moves freely in the groove H I, and to the end that is on the other side of the board, fix the index E, Fig. 4. which, as it ascends and descends, marks the degrees of dryness or moisture on the scale L M.

This hygrometer has not so great an extent as the former, but is more sensible, as having a greater length of string, and no friction of teeth, and it is more easily constructed ; nothing being here necessary but to adjust a proper weight to the end of the string, and to make the pullies move quite free, for which purpose they should be frequently oiled.

But

But the most simple, and at the same time the most sensible hygrometer, may be constructed as follows. Let R S, Fig. 5. be a catgut or whipcord that goes from one end of the room to the other, near the cieling, and passing over the pulley T, descends in a corner of the room to V, where it is fastened to a weight sufficient to keep it always stretched. This weight is to hang free from the wall, and there is to be fastened to it an index X, which points to a scale of wood or paper Z, that is placed against the wall. As this hygrometer has no other friction than that of a single pulley, and may have, in a small room, 18 or 20 feet of string, it is certainly more eligible than either of the foregoing, and perhaps, than any of the numerous and complicated hygrometers that have been invented.

THE

THE THERMOMETER.

THE figure of this instrument, as well as that of the barometer, is too well known to need description. It will be sufficient here to show their construction and the principles on which they act.

As the thermometer is designed to show the degrees of heat and cold by the expansion of a fluid, different fluids have been used for that purpose. The first that became generally used was spirit of wine tinged with cochineal. This thermometer answers very well for common purposes, but in great degrees of heat, as that of boiling water or oil, or melting metals, the spirit will burst the tube; and in a great degree of cold it will freeze. This, therefore was soon rejected by philosophers, and was succeeded by those made with linseed oil; which requires four times the heat to make it boil, that water does.

Fig. 1. p. 9.

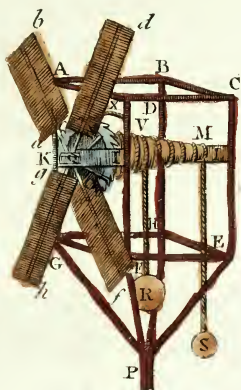


Fig. 2. p. 12.



Fig. 2. p. 12.

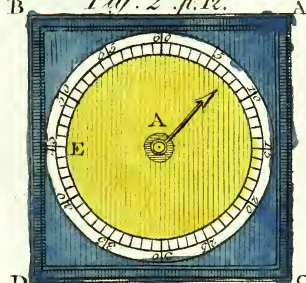


Fig. 5. p. 15.

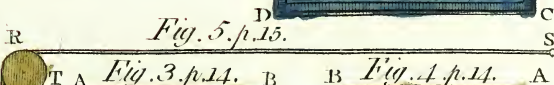


Fig. 3. p. 14.

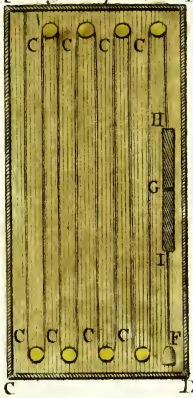
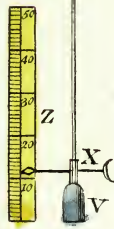
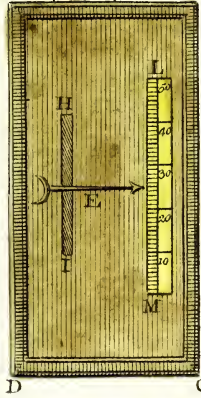


Fig. 4. p. 14.





does. This sort of thermometer was constantly used by Sir Isaac Newton, and with this he measured the comparative heat of boiling water and spirit of wine, and of melting wax, tin and lead ; beyond which it does not appear to have been tried.

There was still wanting a thermometer that would measure any degree of heat, and this was invented by Farenheit of Amsterdam, whose name it still bears. It is made with mercury, which expands itself uniformly from the hardest frost to the greatest heat. The common sort of these thermometers have a scale that begins with 0, the freezing point is 32, and is extended to the heat of boiling water, which is 212 degrees. It was this thermometer the great Boerhaave constantly used in his chemical and other experiments. We forbear any further description of the manner of constructing this instrument, as it cannot be performed to a

degree of accuracy, but by an able workman.

THE BAROMETER.

THIS instrument, when properly constructed, is the most generally useful of all the pneumatic apparatus. The barometer is frequently called the Torricellian tube, from its inventor, an Italian, and disciple of the renowned Galileo, named Torricelli ; who, considering that a column of water of about 33 feet, was equal in weight to a column of air of the same base, concluded that a column of Mercury of about 29 inches and a half would likewise be equal to a column of air, for such a column of mercury he knew to be equal to 33 feet of water ; he accordingly made the experiment, and the apparatus he then used is now the common barometer.

The principal defect in the common barometer is the smallness of the bore of the tube,

tube which occasions the mercury to adhere to its side, and not rise and fall with the necessary freedom. Therefore, procure a glass tube one-third, or at least one-fourth of an inch diameter, hermetically sealed at one end and open at the other, and 34 inches long : its inner surface must be perfectly clean, and that it may be so just before you use it, rub the inside with a piece of fine warm flannel put round a wire. Have ready a small quantity of pure mercury, which you may squeeze through a thin leather. Then quite fill the tube with mercury, and having ready a glass basin, or drinking glass with a flat bottom, about an inch and a half or two inches high, in which likewise some of the same mercury is put, invert the tube, and put it in the basin, still holding your finger under it, till it is in the mercury of the basin ; then place it in a frame. On taking away your finger, the mercury in the tube will immediately subside to about 29 or 30 inches, according to the state of the air,

being very rarely lower than 28, or higher than 31 inches. Therefore if a scale of four inches, divided into tenths, be placed against the upper end of a tube, the barometer is complete.

Though the scale be only divided to tenths of an inch, yet if there be an index from the scale to the tube, as is commonly practised, the eye may distinguish to the 20th or 40th part of an inch, that is to one-half or one quarter of a tenth. But for greater precision there is what they call from its inventor, a Nonius division, which is a small plate so contrived as to slide over the graduated plate or scale, in such manner that its index may always be set, in one part to the surface of the mercury, while another part corresponds with one of the divisions of the scale. Now, this Nonius is divided into ten equal parts, which are together equal to eleven divisions of the scale, that is eleven-tenths of an inch. Consequently
every

every division of the Nonius is equal to one and one-tenth of the scale; two of them to two and two-tenths; three of them to three and three tenths, &c. Whence it is easy to conceive, that if the Nonius index points between any two divisions of the scale, you need only look back to see what division of the Nonius coincides with a division of the scale, and that will show the number of tenths of a tenth; that is, the hundred parts of an inch.

The barometer may be applied to various uses, as measuring the height of towers or mountains; for 12040 inches of air being equal to one inch of mercury, near the surface of the earth, 1204 inches, or 100 feet, must be equal to one-tenth of an inch of mercury. Consequently if a barometer be carried up any great eminence, the mercury will descend one-tenth of an inch for every 100 feet the barometer ascends.

But the great use of the barometer, when well constructed, is that of predicting the future state of the weather, for several hours, and sometimes days, preceding ; though not to a certainty, yet in many instances to a great degree of probability : in order to obtain this desirable end, observe the following rules.

First, The rising of the mercury presages in general, fair weather ; and its falling, foul weather. 2. In very hot weather, the falling of the mercury foreshows thunder. 3. In winter, the rising portends frost ; and in a continued frost it foretells snow. 4. When foul weather happens soon after the falling of the mercury, expect but little of it ; and so on the contrary, of fair weather. 5. But when the mercury continues to rise for some time before the foul weather is over, expect a continuance of fair weather to follow. 6. In fair weather, when the mercury continues to fall before rain comes, then expect a great deal of
of

of it and probably high winds. 7. The unfettled motion of the mercury denotes uncertain or changeable weather.

It appears from these observations, that it is not so much the height of the mercury that indicates the weather, as its motion up or down. Therefore to know whether the mercury be actually rising or falling, observe the following rules. 1. If the surface of the mercury be convex, it is then rising. 2. If the surface be concave, it is then sinking. 3. If the surface be plain, or rather a little convex, it may be considered as stationary. If the tube be small, shake it, and if the air be growing heavier it will rise about half the tenth of an inch, and if it be growing lighter it will sink the same space.

The great utility of the common barometer has induced many persons to invent others, in which the rise and fall of the mercury, and consequently the alterations

the atmosphere, or the height of places, may be more easily observed ; such as the diagonal, the rectangular, the wheel, and pendant barometers, &c. which are in general attended with some peculiar advantages and some defects. But for general use, the common barometer, especially with a Nonius division, is perhaps of all others the most eligible.

In such of the following recreations as are performed by the air-pump, it will be sufficient to have the receiver only in the room where the experiments are made ; and to let the pipe, called the swan's neck, be carried through the frame of the table on which the receiver stands, and communicate with the other parts of the air-pump in an adjoining room, after the same manner as in the articles of electricity and magnetism. By this method the recreations will be heightened by the pleasure of surprise ; a pleasure that many people find much greater, than they are able to express.

R E C R E -

RECREATION I.

The bottles broke by air.

TAKE a bottle that is square, not round or cylindrical; and if it be small, the glass must be thin. Put the mouth of this bottle over the hole in the plate of the air-pump, and exhaust the air. By this mean the bottle will be made to sustain the weight of the external air as long as it is able, but at last it will be suddenly burst into very small parts.

The same effect may be produced by the spring of the air, in the following manner. Seal the mouth of a bottle so close that not the least air can come out, and place it in the receiver; then as the air is drawn off from its surface, the spring of the included air will act against the sides of the bottle, and will
con-

continually increase as the air in the receiver becomes more rarified, till at last it bursts the bottle in pieces.

A similar effect is produced by laying a plate of glass on the top of an open receiver, and exhausting the air ; for then the weight of the external air will press upon the glass and break it in pieces. In like manner if a person lay his hand upon an open receiver, and the air be exhausted, his hand will be fixed to the receiver : for if the aperture of the receiver be four square inches, the weight on his hand will be equal to 60 pound. This experiment will be attended with some pain in the person's hand.

R E C R E -

RECREATION II.

The brass hemispheres.

TAKE two hemispheres of about four inches diameter, and whose circumferences exactly fit each other. Now when they are placed together, and the air is exhausted from their cavities, the internal spring being taken away, they will be pressed by a column of air equal to their surfaces, that is, twelve square inches and a half, which multiplied by fifteen pounds, the weight of the air on every inch, the sum will be 187 pounds and a half.

Therefore, give these hemispheres to any two persons, after they have seen them put together, and that they are not in any manner joined to each other, and desire them to pull the hemispheres asunder ; to effect which they must, between them, exert a force equal to the above number of pounds.

R E C R E-

R E C R E A T I O N III.

Water boiled by air.

TAKE water that is made as warm as you can well bear to put your hand in it, but that has not boiled, and putting it under the receiver exhaust the air. Bubbles of air will soon be seen to rise, at first very small, but presently become larger, and will be at last so great, and rise with such rapidity, as to give the water all the appearance of a violent boiling. This agitation of the water will continue till the air is again let into the receiver, when it will immediately cease, and the water become quite motionless.

R E C R E-

RECREATION IV.

The aerial bubbles.

TAKE a piece of iron, brass, stone, or any other heavy substance, and putting it in a large glass with water, place it in the receiver. The air being exhausted, the spring of that which is in the pores of the solid body, by expanding the particles, will make them rise on its surface in numberless globules, which resembling the pearly drops of dew on the tops of the grass, afford a very pleasing appearance. On letting the air into the receiver all these aerial forms immediately disappear.

RECREATION V.

The floating stone.

TO a piece of cork tie a small stone, that will just sink it, and putting it in a vessel of water, place it under the receiver. Then exhausting the receiver, the bubbles
of

of air which expands from its pores, and adhering to its surface, will render it, together with the stone, lighter, than water, and consequently they will rise to the surface and float.

RECREATION VI.

The withered fruit restored.

TAKE a shriveled apple, and placing it under the receiver exhaust the air. The apple will immediately be plumped up, and look as fair as when first gathered. For the pressure of the external air being taken off, the expansion of that contained within the skin of the apple will extend it to the utmost, so as sometimes to make it burst. This restoration, however, is merely apparent, for the air is no sooner let into the receiver again than the apple returns to its former withered state.

R E C R E-

RECREATION VII.

The vegetable air bubbles.

PUT a small branch of a tree with its leaves, or part of a small plant, in a vessel of water, and placing the vessel in the receiver, exhaust the air. When the pressure of the external air is taken off, the spring of that contained in the air vessels of the plant, by expanding the particles, will make them rise from the orifices of all the vessels, for a long time together, and produce a beautiful appearance. This experiment shows how great a quantity of air is contained in every vegetable substance.

RECRE-

R E C R E A T I O N VIII.

The mercurial rod.

TAKE a piece of stick, cut it even at each end with a penknife, and immerse it in a vessel of mercury. When the air is pumped out of the receiver, it will at the same time come out of the pores of the wood, through the mercury, as will be visible at each end of the stick. When the air is again let into the receiver, it falls on the surface of the mercury and forces it into the pores of the wood, to possess the place of the air.

When the rod is taken out and weighed, it is found to be several times heavier than before, and has changed its colour, being now all over of a bluish hue. If this stick be cut transversely, the quicksilver will be seen to glitter in every part of it.

R E C R E-

RECREATION IX.

The mystical bell.

FIX a small bell to the wire that goes through the top of the receiver, and shaking it by that wire it will be distinctly heard, while the air is in the receiver. As the air is exhausted, the ringing becomes gradually weaker, and at last, how much soever the bell be shook, the least sound cannot be heard. But when the air begins to enter again into the receiver, the sound becomes presently audible. This experiment proves that air is the medium of sound.

RECREATION X.

Feathers heavier than lead.

AT one end of a fine balance hang a piece of lead, and at the other as many feathers as will keep it in equilibrio.

VOL IV.

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Then

Then place the balance under the receiver. As soon as the air begins to be exhausted, the equilibrium will begin to be destroyed, and when all the air is exhausted, the feathers will descend and the lead mount up.

The cause of this phenomenon is plainly deducible from the laws of hydrostatics; for when both bodies are weighed in air, each loses the weight of an equal bulk of air; consequently the feathers will lose a greater weight than the lead; but when the air is taken away, the weight that is restored to the feathers being greater than that restored to the lead, the former will necessarily preponderate.

RECREATION XI.

The self-moving wheel.

TAKE a circle of tin about ten inches diameter, or of any other dimension that will go into the receiver, and to its circumference fix a number of tin vanes, each about an inch square. Let this wheel be placed, between two upright pieces, on an axis whose extremities are quite small, so that the wheel may turn, in a vertical position, with the least force possible. Place the wheel and axis in the receiver and exhaust the air. Let there be a small pipe with a cock; one end of this pipe is to be on the outside of the top of the receiver, and the other end to come directly over the vanes of the wheel.

When the air is exhausted from the receiver, open the cock just mentioned. A current of air will rush against the vanes

of the wheel, and put it in motion ; and the velocity of its motion will increase till the receiver is again replete with air.

If the pump be kept continually working, after the air is exhausted, the motion of this wheel may be regarded not only as spontaneous but perpetual.

R E C R E A T I O N X I I .

The animated figures.

PROVIDE nine, twelve, or any number you please, of hollow cylinders, about nine inches long, and one and a half or two inches diameter. Let the bottom of each of these cylinders be closed, except a small hole ; and in each of them place a piston, like that in a syringe. At the bottom of each piston let there be a worm spring, and over it the figure of a man, woman, or what else you please. These figures should be all different, and in different

ferent attitudes, and of such a size that they may completely enter the cylinders.

Place all the cylinders in a circular frame of wood, and having pushed each piston down to the bottom of the cylinder, and stopped the holes at bottom, draw it up again to what height you think proper, and there will then be a vacuum under each piston. Then place the frame in the receiver, and exhaust the air.

When the weight of the external air begins to be taken off, the force of the spring that is at the bottom of each piston being greater than its friction, and the weight of the figure placed over it, they will all gradually rise up, and present themselves in their proper attitudes. When the air is again let into the receiver, they will in like manner, retire to their separate apartments.

If the arms and legs of the figures be inflated with a due quantity of air, when the pressure of that in the receiver is taken off, they will be extended, and may be made to assume any attitude required ; and when the air is again let into the receiver, they will resume their former positions.

R E C R E A T I O N XIII.

The artificial halo.

PLACE a candle on one side of a receiver, and let the spectator place himself at some distance from the other side. As soon as the air begins to be exhausted, and becomes attenuated and charged with vapours to a proper degree, the light of the candle will be refracted through that medium in circles of various colours, that lively resemble those seen about the moon in a hazy night.

R E C R E -

RECREATION XIV.

The mercurial shower.

CEMENT a piece of wood into the lower part of the neck of an open receiver, and pour mercury over it. After a few strokes of the pump, the pressure of the air on the mercury will force it through the pores of the wood in form of a beautiful shower; which, if the receiver be clear and the weather be dry, will appear luminous in a dark chamber.

RECREATION XV,

The fountain in vacuo.

TAKE a tall glass tube, hermetically sealed at the top and at bottom, by means of a brass cap, screwed on to a stop cock, and that to the plate of the pump. When all the air is exhausted the cock is turned, the tube is taken off the plate

and immerfed in a bafon of mercury or water: then, the cock being again turned, the fluid, by the preffure of the air, will play up in the tube, in form of a fountain, and afford a very pleasing appearance.

There are a great number of other experiments performed by the air-pump; but thefe are quite fufficient to explain the nature of the air's preffure and expansion, which is their general intention.

R E C R E A T I O N XVI.

The air-gun.

THERE are two forts of air-guns, the common, and what is called the magazine air-gun.

The common air-gun is made of brafs, and has two barrels, (Plate III. Fig. 1.) The inner barrel K A, has a smaller bore
than

than the other E C D R. In the stock of the gun there is a syringe S M N P, by which the air is injected into the cavity, between the two barrels, through the valve N P. The ball K is put down the smaller barrel with a rammer, as in other guns. At T L is another valve, which being drawn open by the trigger O, makes way for the air to get behind the ball, and drive it out with great violence. By suddenly opening and shutting the valve, one charge of condensed air will serve for several discharges, which are effected by means of the lock represented in Fig. 2.

In the magazine air-gun there is an additional barrel of a serpentine form, which holds ten or twelve balls, that are brought into the shooting barrel successively, by means of a lever, which is called a hammer.

R E C R E-

R E C R E A T I O N XVII.

Artificial rain and hail.

MAKE a hollow cylinder of wood (Pl. III. Fig. 3.) let it be very thin at the sides, about eight or ten inches wide, and two or three feet in diameter*. Divide its inside into five equal parts, by the boards A. of five or six inches wide ; and let there be between them and the wooden circle a space B. of about one sixth of an inch. You are to observe that these boards are to be placed obliquely, as in the figure.

In this cylinder put four or five pounds of leaden shot, of a size that will easily pass through the opening you have left. Let it turn on the axis D, and be supported by the foot C.

* When this machine is intended for a theatre it must be constructed much larger.

The

The found of this machine when in motion, will strongly represent that of rain, and will increase with the velocity of the motion. To produce the found of hail, a larger sort of shot must be used.

RECREATION XVIII.

The magical flowers and fruit.

MAKE a box A B C D, (Plate III. Fig. 4.) of about six inches every way. In the middle of the top A B, let there be a hole, through which is to pass the neck of the vessel E. that is a kind of hollow copper sphere, of three or four inches diameter, and covered at its top and bottom F and G, with two pieces of the same metal, that are to be well foldered to it. To the part next F there is to be foldered the tube H, about half an inch in diameter, through which is an aperture of a quarter of an inch : this tube must also be pierced horizontally, by an opening of one-

one-third of an inch at I, to admit a cock, the key of which must extend to the outside of the case ; it should also have a small aperture of about one-tenth of an inch, to let out the air that is to be compressed in the vessel E, as we shall now explain.

To force the air into the hollow vessel there must be adjusted to one of its sides the copper syringe N M, Fig. 5, which has a leather valve at M, and another at its extremity N : so that by the alternately thrusting in and drawing out of the piston, the air may be strongly condensed in the vessel E.

To the extremity of the tube H there is to be fixed the little tree O, which is composed of four or five fine branches of copper P, Q, R, S, that proceed from the trunk O. These branches are to be hollow from one end to the other, that the air which enters at the bottom may extend itself to the top To these branches are
to

to be adjusted twigs, made of brass wire, and the whole is to be decorated with orange leaves, that are made of parchment, and strongly imitate those of nature.

The end of each of the branches is to dilate, so that they may contain small pieces of very fine leather, which are to take the figure of an orange, when they are extended by the air drove through the branches. These leathers must be contained within the extremities of the branches, to which they are to be fastened by a silk thread : and there must be a space left at the end of the branch, to which is to be fixed the bud or flower of a blowing orange.

The trunk of the orange-tree must exactly fit the tube H, that none of the air may escape ; and it is to be made to take out. The branches and the leathers that are to form the oranges must be accurately painted, to favour the illusion. There should be a glass cover to the whole, which
will

will prevent any one from touching it ; and the top of the box may be covered with earth.

Previous to the performing this Recreation you take the orange tree out of the case, and with a little stick made for that purpose, you put each of the oranges within the end of the branch, together with the flowers of the blowing oranges ; so that no part of them may appear : and the better to conceal them, the greatest number of leaves may be at the ends of the branches. The tree is then to be replaced in the tube H. You are next to turn the cock at I, and with the syringe throw a sufficient quantity of air into the vessel E.

Matters being thus prepared, you introduce the box and tree covered with the glass ; and make the company observe, that in its present state it bears neither flowers or fruit, and tell them if it be their pleasure it shall instantly



Fig. 1.
p. 40.

Fig. 2. p. 41.



Fig. 3. p. 42.



Fig. 4. p. 43.

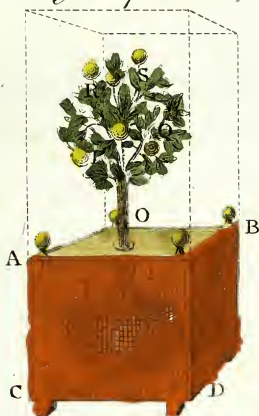


Fig. 5. p. 44.



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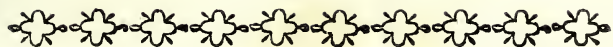
stantly produce both. You then turn the cock *, when the flowers or buds will immediately appear, and will be succeeded by the fruit.

This Recreation may be performed by putting an eolipile in the box instead of the copper vessel ; under which you place a chafing-dish with hot coals, that is to be supposed to produce the sudden vegetation in the tree. The air in the eolipile being rarified by the heat will produce the same effect as the condensed air in the other vessel.

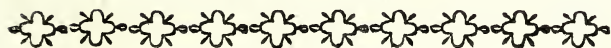
* This cock should be so concealed that you may turn it without being observed by the company.

RECRE-





H Y D R O L O G Y.



VOL. IV.

E

中華民國十年十月

H Y D R O L O G Y.

DEFINITIONS.

1. **H**YDROLOGY is that part of phisiology which explains the properties of water. It is usually divided into hydrostatics and hydraulics; the former of which treats of the manner of weighing water, and fluids in general, and of ascertaining their specific gravities, that is their particular weights; and the other shows the manner of conveying water from one place to another*.

2. A siphon is a bended tube, commonly of a form nearly resembling half an ellipsis.

3. A valve is a sort of flap or cover, fixed to a pipe or other body, which by

* The term hydrostatics is frequently used for a general treatise on water, but certainly with impropriety.

opening one way only, suffers the water to pass, but not to return.

4. A piston is a small cylinder fastened to the end of a rod, and fitted to the bore of a pipe or hollow cylinder, and frequently contains a valve.

5. The hydrometer is an instrument constructed to find the specific gravities of fluids.

6. The hydrostatic balance is contrived to show the specific gravities of fluids and of solids. by weighing them in fluids.

A P H O R I S M S.

1. Water is a scentless, transparent, colourless fluid*, which, with a certain degree of cold, turns to ice.

* Though fluidity be commonly regarded as an essential property of water, yet many philosophers, particularly Boyle and Boerhaave, consider it as an adventitious circumstance, produced by a certain degree of heat, and assert its natural state to be that of a crystalline, as when in ice.

2. Water

2. Water is one of the constituent parts of all bodies*.

3. All fluids, except air, are incompressible †.

4 Though water is less diaphanous than air, it is more penetrative, as it will pervade bodies that air will not ‡.

5. Water dissolves some bodies, as salts, and conglutinates others, as bricks, stones, bones, &c.

6. Water in its natural state, contains

* This is proved by distillation, for the driest woods, earths, bones, and stones pulverised, constantly yield a certain quantity of water. It has been found by experiment, that the water contained in a certain quantity of air was nearly equal to the air itself.

† If a globe of gold be filled with water, and pressed with a very great weight, the water will transude the pores of the gold, and cover the surface of the globe, in the form of a fine dew. This is called the Florentine experiment.

‡ This is evident from its passing through the pores of a bladder.

the three other elements, fire, earth, and air*.

7. The water, in several tubes that communicate with each other, will stand at the same height in all of them, whether they be small or great, perpendicular or oblique.

8. The surface of water contained in a vessel will always be even, and parallel to the horizon †.

9. In a vessel of water the pressure of the upper on the lower parts, is in proportion to the depth ; and is the same at the same depth, whatever be the diameter of the vessel.

* We have already said that water owes its fluidity to heat, and it is evident from many experiments with the air-pump, that it contains no small quantity of air: and the sediment that is found in all water, except that which is distilled, always contains a quantity of earth.

† In large bodies of water, as the sea, or great lakes, the surface will not be plain, but spherical, as making a part of the surface of the terraqueous globe.

10. The

10. The pressure of a fluid upward is equal to its pressure downward, at any given depth*.

11. The bottom and sides of a vessel are pressed by the fluid it contains in proportion to its height, without any regard to the quantity.

12. If fluids of different gravities be contained in the same vessel, the heaviest will be at bottom, the lightest at top, and the

* It follows from this and the preceding aphorism, that the lightest solid may be sunk in the heaviest fluid, as cork in quicksilver, and will remain at the bottom, if it be so contrived that none of the fluid can get under it. On the contrary, the heaviest solid may be suspended in the lightest fluid; if the fluid be of a sufficient depth, and be prevented from pressing on the top of the solid. This is commonly proved by putting a guinea in a tube, exactly of the same diameter, and holding it to the bottom by means of a string. Then, as gold is about nineteen times heavier than water, if you put the tube down in the water to about nineteen times the thickness of the guinea, and let the string go, the guinea will not sink, but be sustained by the pressure of the water under it, which is there greater than the gravity of the guinea.

rest in proportion to their specific gravities.

13. A body that is heavier than an equal quantity of any fluid will sink in that fluid ; if it be lighter, it will swim at the top ; but if it be of the same gravity, it will neither sink nor swim, but remain suspended in any part of that fluid.

14. A solid immersed in a fluid is pressed by that fluid on all sides, in proportion to the height of the fluid above the solid. Bodies very deeply immersed may be considered as equally pressed on all sides.

15. Every solid immersed in a fluid, loses so much of its weight, as is equal to a weight of a quantity of that fluid of the same dimension with the solid*.

* It is on this aphorism that the hydrostatic balance is founded : for if every solid, on being immersed in a fluid, loses so much of its weight as is equal to the weight of an equal bulk of that fluid, it follows that the lighter the body is, the greater proportion of its weight it will lose ; therefore, if

two

16. The fluid acquires the weight the solid loses.

two bodies of equal bulk be first weighed in air, and then in water, and it be found that one has lost half of its weight, and the other one-fourth, it follows that the specific gravity of the latter is to that of the former as 2 to 1. From hence also is derived the method of finding the specific gravity of fluids, for if the same solid when weighed in two different fluids, loses twice as much in one as in the other, it follows that the specific gravity of the former must be twice as great as that of the latter.

THE

THE HYDROLOGIC APPARATUS.

AMONG the hydrologic apparatus, the syphon claims the first regard, and that as well from its simplicity, as its utility in explaining the more complex machines.

If the syphon EFG (Plate IV. Fig. 1.) be immersed in the vessel of water ABCD, and the air sucked out at E*, the pressure of the air upon the surface of the water in the vessel will force it up the vacuity in the pipe from G, and passing through the top in at F, it will descend in the other leg, and run out at E, as long as the surface of the water is above the bottom of the leg CG. You must observe, however, that to make the water run out, the end E of the

* If the syphon or crane be filled with water, then inverted, and one end placed in a vessel of water, it will have the same effect as drawing out the air, and when the syphon is large, will be more easily effected.

syphon

fyphon must be below G : for if both ends be parallel, the pressure of the air on each end will be equal, and the water will remain in the fyphon.

It is to be remembered, that the top of the fyphon must not exceed 32 feet perpendicular altitude above the surface of the water in the vessel ; for a column of air of the height of the atmosphere is but just equal to a column of water of 32 feet. Mercury may be drawn through a fyphon in the same manner, as water ; but then the utmost height of the fyphon must always be less than 30 inches, as mercury is near 14 times heavier than water. That fluids are forced through the fyphon by the pressure of the atmosphere is proved experimentally by the air-pump ; for if a fyphon immersed in a vessel of water be placed, when running, in the receiver, and the air extracted, the running will immediately cease.

There

There is a sort of syphon that will draw off water without having the air previously extracted from it : this consists of a capillary tube, about one tenth of an inch bore, and acts by the attraction of cohesion : for the water being attracted by the leg immersed, is slowly drawn up to the top of the syphon, and from thence gradually descends by its gravity. From the same cause it is, that if one end of a piece of the list of cloth be put in the water of a vessel, and the other end hang over its side, the water will be sucked up by the end of the list, in the vessel, which in this case acts as a bundle of very fine capillary tubes, and drop from the other end. This experiment with a capillary tube will succeed in vacuo.

THE

THE P U M P.

THE pump is at once the most common and most useful of all hydraulic instruments. Of pumps there are three sorts, the sucking, forcing and lifting pump.

A B (Pl. IV. Fig. 2.) is the pipe or barrel of a common sucking pump, C D the piston or bucket, E F two valves that open upward. When the handle of the pump is put down it raises the bucket, and the valve F shuts. The water above the bucket being raised, a vacuum is left under it, and the external air pressing on the water in the well M N, raises it up, through the hole B, and lifting up the valve E, enters the barrel of the pump. The handle of the pump being then raised, the bucket descends, the valve F opens, and lets the water ascend above the bucket. The pressure of the water at the same time
shuts

shuts the valve E, so that it cannot return through B. The handle being again preffed down the bucket is again raised, and more water ascends through B. So that at every stroke of the handle, the water in the barrel is increased, till at last it runs out at the pipe H.

If the bucket be more than 30 or 32 feet from the surface of the water in the well, it will not ascend to the bucket, for the pressure of the atmosphere, as we have before observed, is but equal to 32 feet of water. The weight the bucket lifts at each stroke, is equal to a column of water whose diameter is that of the bore of the pump and its height M H. It is therefore of no consequence where the bucket is placed, with regard to the weight of water. To balance that weight the handle should be made heavy. The piston or bucket must be surrounded with leather, that it may exactly fit the bore of the pump, at the same time it moves freely
up

up and down. The valves also should move free, and shut quite close. The smaller the bore of the pump, the easier it will work ; but the wider it is, and the longer the stroke of the handle, the more water it will raise.

The forcing pump is constructed as follows : A B (Pl. IV. Fig. 3.) is the barrel standing in the water of the well at B. C is the piston, and G the handle : C is a solid piece, without any valve, as no water is to pass thro' it : this piece should be carefully leathered, and made to fit the barrel so exactly, that in its motion neither water nor air may pass between them. At a distance below, as at D, a valve is fixed. Between this and the lowest situation of the piston C, there goes off a pipe H, in which is fixed a valve at E.

Now the piston being drawn up from C towards A, exhausts or rarifies the air above D, which causes the water to rush into the space C D ; and when the piston
is

is forced down, as the water cannot repass at D, it is forced to ascend into the pipe H, and through its valve E into the cistern F (which may be placed at any distance from the pump) and from thence it runs off by the spout.

Of lifting pumps there are several sorts; the most common is thus constructed. AB (Pl. IV. Fig. 4.) is the barrel, fixed in the frame K I L M; which is also fixed immoveable, with the lower part in the water that is to be pumped up. GEQHO is a frame with two strong iron rods, moveable through holes in the upper and lower parts of the pump, IK and LM. In the bottom of this frame is fixed an inverted piston B D, with its bucket and valve uppermost at D. From the top of the barrel there goes off a part K H, either fixed to the barrel, or moveable by a ball and socket (as here represented at F). but in either case so very exact and tight, that no water or air can possibly get into the barrel, as
that

Fig. 1. p 58.

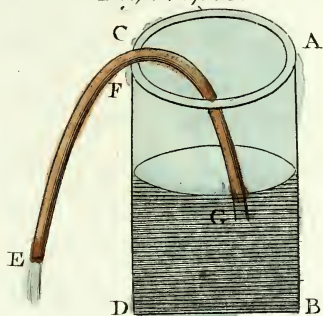


Fig. 2. p 61.

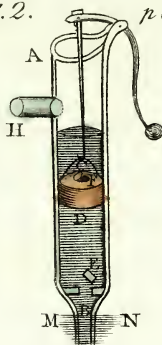


Fig. 3. p 63.

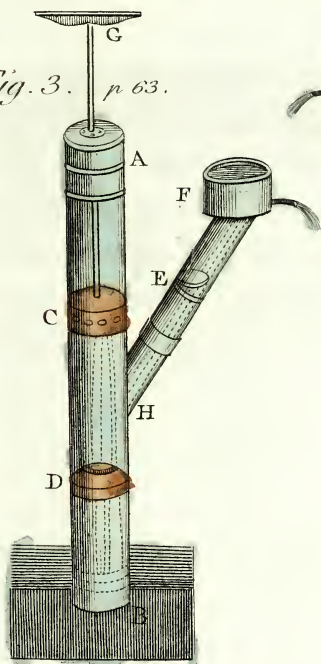
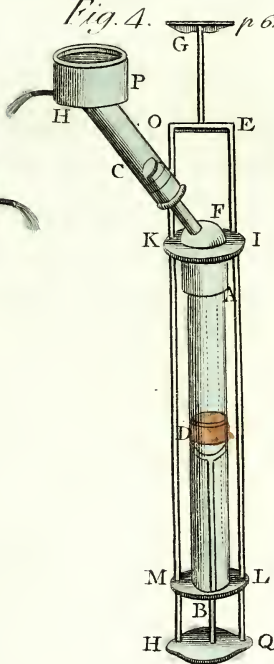


Fig. 4. p 64.





that would prevent the effect of the pump. In this part, at C, is fixed in a valve opening upward.

When the piston frame is thrust down into the water, the piston D will descend, and the water beneath it rush up through the valve at D, and get above the piston ; where, upon the frames being lifted up, the piston will force the water through the valve C, into the cistern P, there to run off by the spout. It is to be remembered, that this sort of pump must be set so far in the water, that the piston may play below its surface. It appears by the above description, that this is only a different manner of constructing a forcing pump.

T H E H Y D R O M E T E R.

THIS is the most eligible of all instruments for finding the specific gravity of fluids only, as well for ease as expedition.

The globe of the hydrometer should be made of copper, for ivory imbibes spiritous liquors, and thereby alters their gravity, and glass requires an attention that is incompatible with expedition. The most simple hydrometer consists of a copper ball, *B b* (Plate 5. Fig. 1.) to which is foldered a brass wire *A B*, one quarter of an inch thick. The upper part of this wire being filed flat is marked *proof*, at *m*, Fig. 2. because it sinks exactly to that mark in proof spirits: There are two other marks at *A* and *B*, Fig. 1. to shew whether the liquor be one tenth above or below proof, according as the hydrometer sinks to *A*, or emerges to *B*,
when

when a brass weight, as C or K, is screwed to its bottom c. There are other weights to screw on, which shew the specific gravity of different fluids, quite down to common water.

The round part of the wire above the ball, may be marked so as to represent river water when it sinks to R W, Fig. 2. the weight which answers to that water being then screwed on; and when put into spring water, mineral water, sea water, and water of salt springs, it will gradually rise to the mark SP, MI, SE, SA. On the contrary, when it is put into Bristol water, rain water, port wine, and mountain wine, it will successively sink to the marks *br*, *ra*, *po*, *mo*. Instruments of this kind are sometimes called areometers.

There is another sort of hydrometer that is calculated to ascertain the specific gravity of fluids to the greatest precision possible, and which consists of a large hol-

low ball B (Plate V. Fig. 3.) with a smaller ball *b* screwed on to its bottom, partly filled with mercury or small shot, in order to render it but little specifically lighter than water. The larger ball has also a short neck at C, into which is screwed the graduated brass wire AC, which by a small weight at A, causes the body of the instrument to descend into the fluid, with part of the stem.

When this instrument is swimming in the liquor contained in the jar ILMK, the part of the fluid displaced by it, will be equal in bulk to the part of the instrument under water, and equal in weight to the whole instrument. Now, suppose the weight of the whole to be four thousand grains, it is then evident we can by this mean compare the different dimensions of four thousand grains of several sorts of fluids. For if the weight at A, be such as will cause the ball to sink in rain water, till its surface comes to the middle point
of

of the stem 20, and after that if it be immersed in common spring water, and the surface be observed to stand at one-tenth of an inch below the middle point 20, it is apparent that the same weight of each water, differs only in bulk by the magnitude of one-tenth of an inch in the stem.

Now suppose the stem to be ten inches long, and weight a hundred grains, then every tenth of an inch will weigh one grain ; and as the stem is of brass, which is about eight times heavier than water, the same bulk of water will be equal to one-eighth of a grain and consequently to the one-eighth of one-four thousandth part, that is, one thirty-two thousandth part of the whole bulk. This instrument is capable of still greater precision, by making the stem or neck consist of a flat thin slip of brass, instead of one that is cylindrical : for by this mean we increase the surface, which is the most requisite circumstance, and diminish the solidity,

which necessarily renders the instrument still more accurate.

To adapt this instrument to all purposes, there should be two stems, to screw on and off, in a small hole at *a*. One stem should be a smooth thin slip of brass, or rather steel, like a watch-spring set straight, similar to that we have just mentioned, on one side of which is to be the several marks or divisions to which it will sink in different sorts of water; as rain, river, spring, sea, and salt spring waters, &c, and on the other side you may mark the divisions to which it sinks in various lighter fluids, as hot Bath water, Bristol water, Lincomb water, Cheltenham water, port wine, mountain, madeira, and other sorts of wines. But here the weight at A on the top must be a little less than before, when it was used for heavier waters.

But in trying the strength of the spiritous liquors a common cylindric stem will

will do best, because of its strength and steadiness: and this ought to be so contrived, that when immersed in what is called proof spirit, the surface of the spirit may be upon the middle point 20: which is easily done by duly adjusting the small weight A, on the top, and making the stem of such a length, that when immersed in water, it may just cover the ball and rise to a ; but when immersed in pure spirit, it may rise to the top A. Then by dividing the upper and lower parts a 20 and A 20, into ten equal parts each, when the instrument is immersed in any sort of spiritous liquor it will immediately show how much it is above or below proof.

Proof spirit consists of half water, and half pure spirit, that is, such as when poured on gunpowder, and set on fire, will burn all away; and permits the powder to take fire and flash as in open air. But if the spirit be

not so highly rectified, there will remain some water, which will make the powder wet, and unfit to take fire. Proof spirit of any kind, weighs seven pounds twelve ounces per gallon.

The common method of shaking the spirits in a phial, and raising a head of bubbles, to judge by their manner of rising or breaking whether the spirit be proof, or near it, is very fallacious. There is no way so certain, and at the same time so easy and expeditious, as this by the hydrometer : which will infallibly demonstrate the difference of bulks, and consequently the specific gravities in equal weights of spirits, to the thirty, forty, or fifty thousandth part of the whole, which is a degree of accuracy no one can wish to exceed.

THE

THE HYDROSTATIC BALANCE.

THOUGH the hydrometer is the most convenient instrument for measuring the specific weights of fluids, yet for a measure of the specific gravity of all substances, we must have recourse to the hydrostatic balance : which is constructed in various forms, but we shall content ourselves here with describing that which appears of all others the most accurate.

VCG, (Pl. V. Fig. 4.) is the stand or pillar of this hydrostatic balance, which is to be fixed in a table. From the top A, hangs, by two silk strings, the horizontal bar BB, from which is suspended by a ring *i*, the fine beam of a balance *b* ; which is prevented from descending too low on either side by the gentle springing piece *l x y z*, fixed on the support M. The harness is annulated at *o*, to shew distinctly
the

the perpendicular position of the examen, by the small pointed index fixed above it.

The strings by which the balance is suspended, passing over two pullies, one on each side the piece at A, go down to the bottom on the other side, and are hung over the hook at *v*; which hook, by means of a screw P, is moveable, about one inch and a quarter, backward and forward, and therefore the balance may be raised or depressed so much. But if a greater elevation or depression be required, the sliding piece S, which carries the screw P, is readily moved to any part of the square brass rod VK, and fixed by means of a screw.

The motion of the balance being thus adjusted, the rest of the apparatus is as follows. HH is a small board, fixed upon the piece D, under the scales *d* and *e* and is moveable up and down in a long slit

slit in the pillar, above C, and fastened at any part by a screw behind. From the point in the middle of the bottom of each scale hangs, by a fine hook, a brass wire *a d*, and *a c*. These pass through two holes *m m*, in the table. To the wire *a d* is suspended a curious cylindric wire *r s*, perforated at each end for that purpose: this wire *r s* is covered with paper, graduated by equal divisions, and is about five inches long.

In the corner of the board at E, is fixed a brass tube, on which a round wire *h l* is so adapted as to move neither too tight nor too free, by its flat head I. Upon the lower part of this moves another tube Q, which has sufficient friction to make it remain in any position required: to this is fixed an index T, moving horizontally when the wire *h l* is turned about, and therefore may be easily set to the graduated wire *r s*. To the lower end of the wire *r s* hangs a weight L, and to that a
wire

wire pn , with a small brass ball g , about one-fourth of an inch diameter. On the other side, to the wire ac , hangs a large glass bubble R , by a horse hair.

Let us first suppose the weight L taken away, and the wire pn suspended from S ; and on the other side, let the bubble R be taken away, and the weight F suspended at c in its room. This weight F we suppose to be sufficient to keep the several parts hanging to the other scale in equilibrium; at the same time that the middle point of the wire pn is at the surface of the water in the vessel N . The wire pn is to be of such a size that the length of one inch shall weigh four grains.

Now it is evident, since brass is eight times heavier than water, that for every inch the wire sinks in the water it will become half a grain lighter, and half a grain heavier for every inch it rises out
of

of the water : consequently, by sinking two inches below the middle point, or raising two inches above it, the wire will become one grain lighter or heavier. Therefore, if when the middle point is at the surface of the water in equilibrio, the index T , be set to the middle point a , of the graduated wire rs , and the distance on each side ar and as contains a hundred equal parts, then, if in weighing bodies the weight is required to the hundredth part of a grain, it may be easily had by proceeding in the following manner.

Let the body to be weighed be placed in the scale d . Put the weight X in the scale e , and let this be so determined, that one grain more shall be too much, and one grain less, too little. Then the balance being moved gently up and down, by the screw P , till the equilibrium be nicely shewn at o ; if the index T be at the middle point a of the wire rs , it shews that the weights put into the scale e are just equal

equal to the weight of the body. By this method we find the absolute weight of the body : the relative weight is found by weighing it hydrostatically in water as follows.

Instead of putting the body into the scale *d*, as before, let it hang with the weight *F*, at the hook *c*, by a horse-hair, as at *R*, supposing the vessel *O* of water taken away. The equilibrium being then made, the index *T* standing between *a* and *r*, at the thirty-sixth division, shews the weight of the body put in to be 1095,36 grains. As it thus hangs, let it be immersed in the water of the vessel *O*, and it will become lighter : the scale *e* will descend till the beam of the balance rest on the support *z*. Then suppose a hundred grains put into the scale *d* restore the equilibrium precisely, so that the index *T* stands at the thirty-sixth division above *a* : it is evident that the weight of an equal bulk of water would, in this case be exactly a hundred grains.

After

Fig. 1. p. 66.

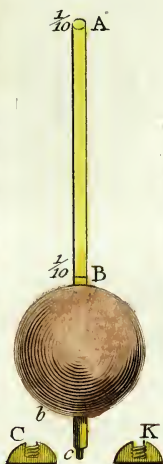


Fig. 2. p. 67.

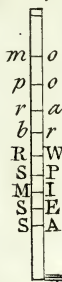


Fig. 3. p. 68.

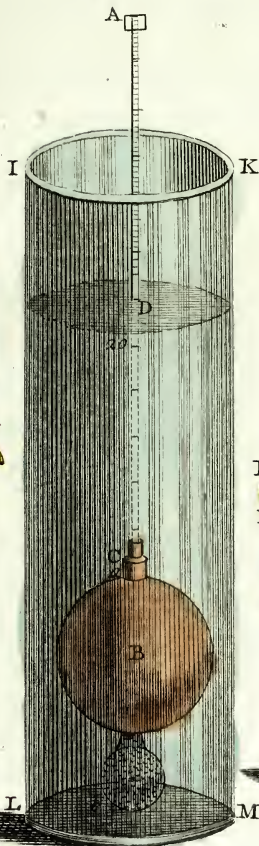
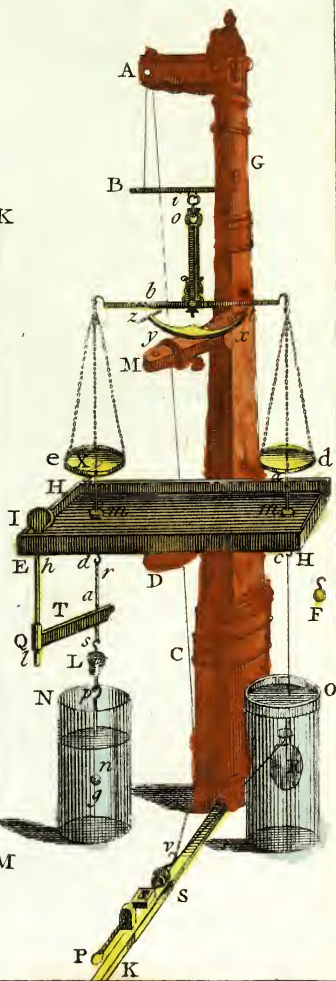


Fig. 4. p. 73.





After a like manner this balance may be applied to find the specific gravity of liquids, as is easy to conceive from what has been said.

THE SCREW OF ARCHIMEDES.

THIS is a sort of spherical pump, and receives its name from its inventor. It consists of a long cylinder AB (Pl. VI. Fig. 1.) with a hollow pipe CD round it: and is placed in an oblique position, with the lower end in the water, the other end being joined to the lower end of the winch IK, supported by the upright piece IR.

When this screw is immerfed in the water, it immediately rises in the pipe, by the orifice C, to a level with the surface of the water EF, and if the point in the spiral, which in the beginning of the motion is coincident with the surface of the water, happen not to be on the lower side of the cylinder, the water upon the motion of the screw, will move on in the spiral, till
it

it come to the point on the other side that is coincident with the water. When it arrives at that point, which we will suppose to be O, it cannot afterwards possess any other part of the spiral than that on the lowest part of the cylinder : for it cannot move from O towards H or G, because they are higher above the horizon : and as this will be constantly the case, after the water in the spiral has attained the point O, it is plain it must always be on the under side of the cylinder.

But because the cylinder is in constant motion, every part of the spiral screw, from O to D, will by degrees succeed to the under part of the cylinder. The water therefore must succeed to every part of it, from O to D, as it comes on the lower side, that is, it must ascend on the lower part of the cylinder, through all the length of the pipe, till it come to the orifice at D, where it must run out, having nothing further to support it.

T H E

THE BALANCE PUMPS.

THIS is a simple and easy method of working two pumps at once, by means of the balance A B, (Plate VI. Fig. 3.) Having a large iron ball at each end, and placed in equilibrio on the two spindles C, as represented in the 4th figure. On the right and left are two boards I, nailed to the two cross-pieces, fastened to the axis of the machine. On these boards the person who is to work the pump stands, and supports himself by a cross piece, nailed to the two posts ED, Fig. 3. At the distance of ten inches on each side the axis, are fastened the piston rods M N.

The man, by leaning alternately on his right and left foot, puts the balance in motion by which the pumps O P, are worked, and the water thrown into the pipe H, and carried to a height proportional to the diameter of the valves,

and the force of the balance. There must be placed on each side an iron spring, as F and G, to return the balance, and prevent its acquiring too great velocity.

THE HYDRAULIC SCOOP.

THIS machine consists of five pieces of board, forming a sort of scoop as B, (Plate VI. Fig. 2.) The handle C is suspended by a rope, fastened to three poles, placed in a triangle, and tied together at A.

The working of this machine consists entirely in balancing the scoop that contains the water, and directing it in such manner that the water may be thrown in any given direction. It is evident that the operation of both this and the last machine is so very easy, that it may rather be considered as an agreeable and salutary recreation, than hard labour.

With

With this machine a man of moderate strength, by two strokes in four seconds, can draw half a cubic foot of water, that is, more than four hundred cubic feet in an hour.

This machine is frequently used by the Dutch in emptying the water from their dykes.

R E C R E A T I O N X I X .

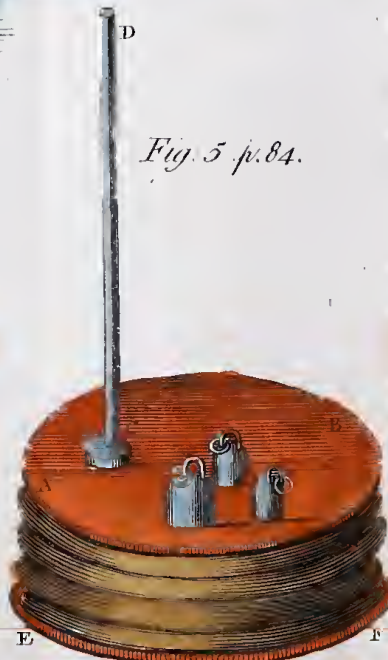
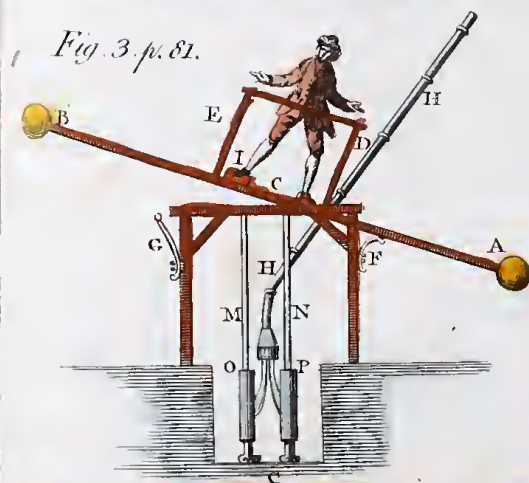
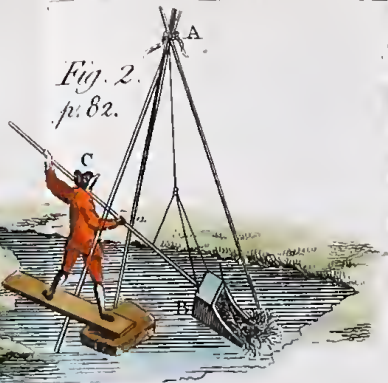
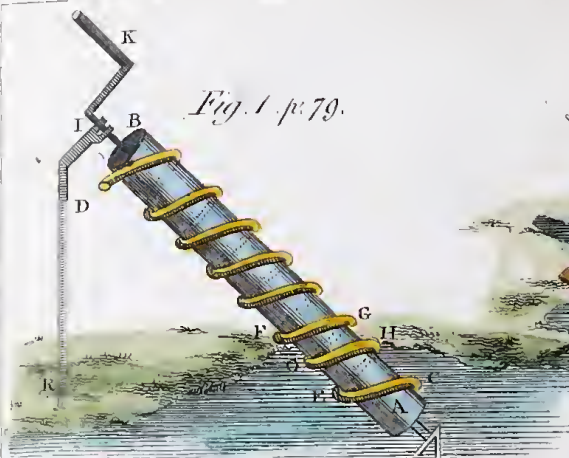
The hydrostatic bellows.

LET AB and EF, (Pl. VI. Fig. 5.) be two circular boards of Oak : the sides AE and BF are to be of leather, and joined very close to the top and bottom by strong nails. CD is a pipe screwed into a piece of brass on the top board, at C.

Now if a man blow into the pipe DC, he may raise a very heavy weight placed on the top of the bellows. Or if he stand on the top AB, he will, by blowing strongly into the pipe, soon blow himself up.

If water be poured in at D, till the bellows and pipe be full, the pressure against AB, on the inside, will lift as much weight on the top, as is equal to a cylinder of water, whose base is AB, and its height CD.

R E C R E -





RECREATION XX.

The water clock.

PROVIDE a cylindric vefsel of glafs, or china, ABCD (Pl. VII. Fig. 1.) about a foot high, and four inches diameter. Make a hole in its bottom, in which glue a fmall glafs tube E, of about one-third of an inch diameter, and whose end has been partly clofed in the flame of a lamp, fo that it will not fuffer the water to pafs out but by drops, and that very flowly. Cover the top of the vefsel with a circle of wood F, in the center of which make a round hole about half an inch diameter.

Have a glafs tube G H, a foot high, and a quarter of an inch diameter, and at one end let it have a fmall glafs globe I, to which you may hang a weight L, by which it is kept in equilibrio, on or near the furface of the water ; or you may pour a

G 3 fmall

small quantity of mercury into the tube, for the same purpose. Fill the vessel with water ; put the tube in it ; and over it place the cover F, through the hole of which the tube must pass freely up and down. Now, as the water drops gradually out of the vessel, the tube will continue to descend till it come to the bottom.

Therefore, paste on the tube a graduated paper, and put it in the vessel when nearly full of water. Hang a watch by it, set to a certain hour, and as the tube descends, mark the hours, with the half and quarter hours. If the vessel be sufficiently large, with regard to the hole at the bottom, it will go for twelve hours, a day, or as much longer as you please, and requires no other trouble than that of pouring in water to a certain height. Care must be had however that the water be clean, for if there be any sediment it will in time stop the
small

small hole at bottom, or at least render the motion of the water irregular.

The vessel may be of tin, but the pipe at bottom should be glass, that its small aperture may not alter by use. It is to be observed, that the tube of one of these clocks is not to be graduated by another, for though the vessel be of the same diameter at top, it may not be perfectly cylindrical throughout ; nor is it easy to make the hole at the bottom of one vessel exactly of the same dimension with that of another.

R E C R E A T I O N XXI.

The globular fountain.

MAKE a hollow globe A, (Pl. VII. Fig. 4.) of copper or lead, and of a size adapted to the quantity of water that comes from the pipe to which it is to be placed. Pierce a number of small holes through this globe, that all tend toward its center*. Annex to it a pipe B, of such height as you think convenient, and let it be screwed at C, to the pipe from whence the jet flows.

The water that comes from the jet rushing with violence into the globe, will be forced out at the holes, with the direction in which they are made, and will produce a very pleasing sphere of water.

* The diameters of all these holes, taken together, must not exceed that of the pipe at the part from whence the water flows.

R E C R E-

R E C R E A T I O N XXII.

The hydraulic dancer.

PROCURE a little figure, made of cork, as AB, (Pl. 7. Fig. 2.) which you may paint or dress in a light stuff, after your own fancy. In this figure you are to place the small hollow cone C, made of thin leaf brass.

When the figure is placed on the jet-d'eau that plays in a perpendicular direction, it will remain suspended on the top of the water, and perform a great variety of motions.

If a hollow ball of copper, of an inch diameter, and very light, be placed on a similar jet, it will in like manner, remain suspended, revolving on its center, and spreading the water all round it, in the manner represented by Fig. 3.

R E C R E-

R E C R E A T I O N XXIII.

The hemispherical cascade.

MAKE a hollow leaden cone A, (Pl. VII. Fig. 5.) whose axis is one-third of the diameter of its base. The circle C, that forms the base must be in proportion to the surface of water that flows from the jet on which it is to be placed, that it may flow from it equally on all sides. To the cone join the pipe B, which serves not only as a support, but is to be pierced with a number of holes, that it may supply the cone with a sufficient quantity of water. Screw the tube just mentioned to the top of that from whence the jet proceeds.

The water that rushes into the cone from the pipe, will run over its circumference, and form a hemispherical cascade. If this piece be so constructed that it may
be

be placed in a reversed position, it will produce a fountain in the form of a vase, (see Fig. 6.) and if there be a sufficient quantity of water, both these pieces may be placed on the same pipe. The fountain at top and the cascade underneath; which by their variety, will produce a very pleasing appearance.

RECREATION XXIV.

The water sun.

LET there be two portions of a hollow sphere, (Plate VII. Fig. 7.) that are very shallow: and let them be so joined together, that the circular space between them may be very narrow. Fix them vertically to a pipe from whence a jet proceeds. In that part by which the portions of the sphere are joined, there must be made a number of holes; then the water rushing into the narrow cavity will be forced out from the holes, and produce a regular

regular figure of the sun, as in the plate, This piece requires a large quantity and force of water, to make it appear to advantage.

Several pieces of this sort may be placed over each other, in a horizontal direction, and so that the same pipe may supply them all with water, (see Fig. 8.) It is proper to observe, that the diameter of these pieces must continually diminish, in proportion to their distance from the bottom.

RECREATION XXV.

The revolving water sun.

MAKE a hollow circle A, (Plate VIII. Fig. 1.) the sides of which are to be pierced with nine, twelve, or fifteen holes, made in an inclined direction : or you may place the like number of small tubes

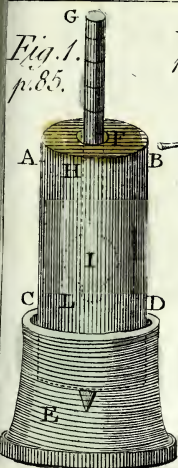


Fig. 5. p. 90.



Fig. 3.
p. 89.

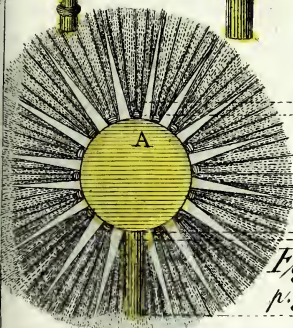


Fig. 8. p. 92.

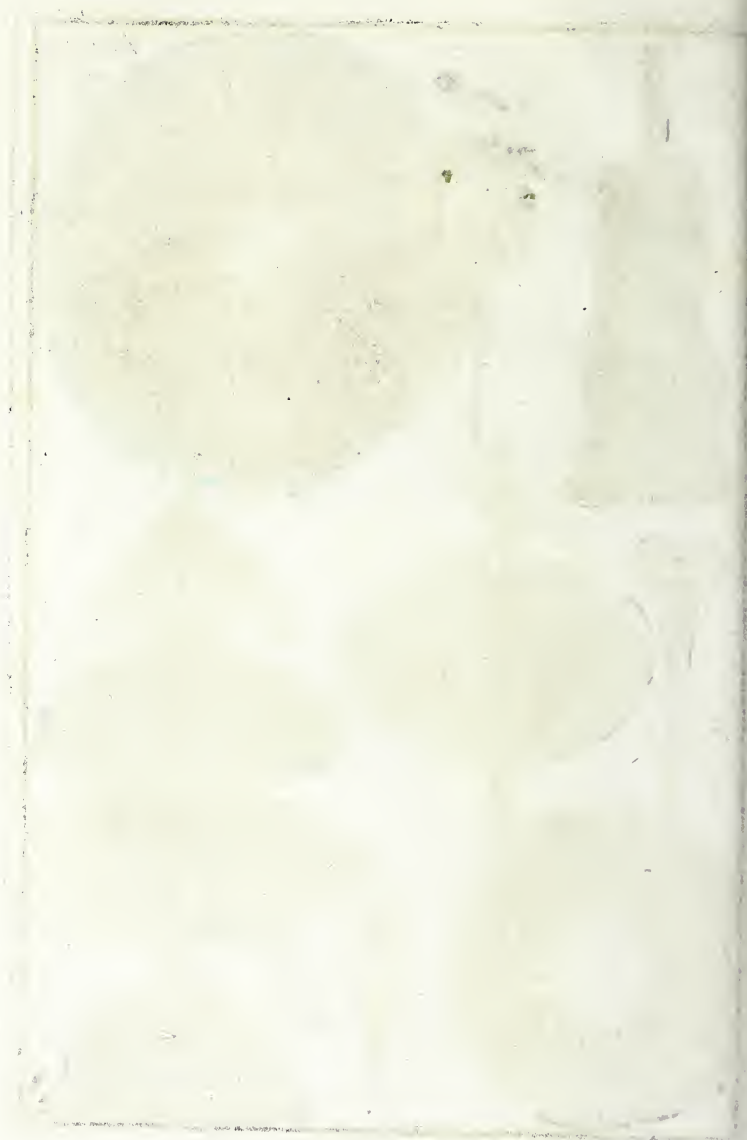


Fig. 6.
p. 91.



Fig. 7.
p. 91.





tubes round the circle. Fix this circle on the top of a jet, in such manner that it may turn freely round.

The water rushing violently into the hollow circle will keep it in continual motion ; and at the same time forcing itself out of the holes or small tubes, will form a revolving figure, with rays in different directions, as in the plate.

R E C R E A T I O N XXVI.

The phial of the four elements.

TAKE a phial six or seven inches long, and about three quarters of an inch diameter. In this phial first put glass grossly powdered : secondly, oil of tartar per deliquum ; thirdly, tincture of salt of tartar ; and fourthly distilled rock oil.

The glass and the different liquors being of different densities, if you shake the
phial,

phial, and then let it rest for a few moments, the three liquors will intirely separate, and each one assume its proper place, according to its specific gravity. The powdered glass at the bottom of the phial may be supposed to represent earth ; the oil of tartar, which occupies the second place, represents water : the tincture that floats above it may be compared to the air ; and the rock oil which swims at the top, is supposed to represent the element of fire.

RECREATION XXVII.

The magic bottle.

TAKE a small bottle AB, (Pl. VIII. Fig. 2.) the neck of which must be very narrow*, and have a glass vessel CD, whose height exceeds that of the bottle about two inches.

With a small funnel fill the bottle quite full of red wine, and place it in the vessel

* The mouth of this bottle should not be more than one sixth of an inch wide.

C D,

C D, which is to be full of water. The wine will presently come out of the bottle, and rise, in form of a small column, to the surface of the water ; and at the same time the water entering the bottle, will supply the place of the wine ; for water being specifically heavier than wine, must hold the lowest place, while the other naturally rises to the top.

A similar effect will be produced if the bottle be filled with water, and the vessel with wine. For the bottle being placed in the vessel, in an inverted position, the water will descend to the bottom of the vessel, and the wine will mount into the bottle. The same effect may be produced by many other liquors, whose specific gravities are considerably different.

R E C R E A T I O N XXVIII.

The compressed jet d'eau.

PROVIDE a strong copper vessel A, (Plate VIII. Fig. 6.) of such figure as you think convenient ; in which solder a pipe BE, of the same metal. Let there be a cock at H, which must be made so tight that no air can pass by it. The pipe BE must go very near the bottom of the vessel, but not touch it. There must be another pipe F, at whose extremity G there is a very small hole : this pipe must be screwed into the former.

The vessel being thus disposed, take a good syringe, and placing the end of it in the hole, at G, open the cock, and force the air into the vessel : then turn the cock, and take out the syringe. Repeat this operation several times, till the air in the vessel be strongly condensed. Then fill the
syringe

fyringe with water, and force it into the vefſel, in the ſame manner as you did the air ; and repeat this operation till you can force no more water into the vefſel ; then ſhut the cock.

This vefſel will be always ready to perform an extempore jet d'eau : for on turning the cock the ſpring of the compressed air will force out the water with great violence, and the jet will continue, tho' continually decreaſing in force, till the water is all exhausted, or the air within the vefſel is come to the ſame denſity with that without.

R E C R E A T I O N XXIX.

The marvellous vessel.

LET there be made a tin vessel, about six inches high, and three inches in diameter, (Pl. VIII. Fig. 3.) The mouth of this vessel B, must be only one quarter of an inch wide; and in its bottom at A, make a great number of small holes, about the size of a common sewing needle.

Plunge this vessel in water, with its mouth open, and when it is full, cork it up, and take it out of the water. So long as the vessel remains corked, no water whatever will come out, but as soon as it is uncorked, the water will issue from the small holes at its bottom.

You must observe, that if the holes at the bottom of the vessel be more than one-sixth of an inch diameter, or if they be
in

in too great number, the water will run out though the vessel be corked; for then the pressure of the air against the bottom of the vessel will not be sufficient to confine the water.

A Recreation similar to this is made with a glass filled with water, over which a piece of paper is placed. The glass is then inverted, and the paper drawn dextrously away, when the water by the pressure of the air under it, will remain in the glass.

RECREATION XXX.

The circulating fountain.

IN this fountain the boxes C E and D X (Pl. VIII. Fig. 5.) being close, you see only the basin A W, with a hole at W, through which the water that spouts out at B falls, and runs down, through the pipe WX, into the box DX, from whence

H 2

it

it drives out the air, through the ascending pipe YZ , into the cavity of the box CE , where pressing upon the water contained in that box, it forces it out thro' the spouting pipe OB , as long as there is any water in CE ; so that the continuance of the play is while the water in CE spouts out and falls down through the pipe WX , into the cavity DX .

The force of the jet is in proportion to the height of the pipe WX , or of the distance between the boxes CE and DX . The height of the water, measured from the basin AW to the surface of the water in the lower box DX , is always equal to the height, measured from the top of the jet to the surface of the water in the middle cavity CE . Now, since the surface CE is always falling, and the water DX is always rising, the height of the jet must continually decrease, till it is shorter by the depth of the cavity CE , which is emptying, added to the depth of
the

the cavity D X, which is always filling ; and when the jet is fallen so low, it immediately ceases.

The method of preparing this fountain is as follows. First, pour water in at W, till you have filled the cavity D X, then turn the fountain over, and the water will run from the cavity D X, into the cavity C E, which you will know to be full by the water's running out at B, when it is held down. Set the fountain up again, and pour about a pint of water into the basin at A W, and as soon as it has filled the pipe W X, the fountain will play, and continue as long as there is any water in C E. You may then empty the water left in the basin into any other vessel, and invert the fountain : which upon being placed again erect, will begin to play, when the water poured out of the basin is put into it again. There are fountains of this sort that have four pipes, instead of two, and by that mean

H 3 the

the water is forced up to twice the height it is in this.

RECREATION XXXI.

The magical cascade.

PROCURE a tin vessel AB, (Plate VIII. Fig. 4.) five inches high and four in diameter ; with a cover C, closed at top. To the bottom of this vessel let there be foldered the pipe DE, of ten inches length and half an inch in diameter : this pipe must be open at each end, and the upper end must be above the water in the vessel. To the bottom also fix five or six small tubes F, about one-eighth of an inch diameter. By these pipes the water contained in the vessel is to run slowly out.

Place this machine on a sort of tin basin GH, in the middle of which is a hole of one quarter of an inch diameter. To the tube DE fix some pieces that may support the vessel over the basin, and observe

serve that the end D, of the tube D E, must be little more than one quarter of an inch from the bafon. There must be also another vessel placed under the bafon to receive the water that runs from it.

Now, the small pipes discharging more water into the bafon than can run out at the hole in its center, the water will rise in the bafon, above the lower end of the pipe D E, and prevent the air from getting into the vessel A B, and consequently the water will cease to flow from the small pipes. But the water continuing to flow from the bafon, the air will have liberty again to enter the vessel A B, by the tube D E, and the water will again flow from the small pipes. Thus they will alternately stop and flow, as long as any water remains in the vessel A B.

As you will easily know, by observing the rise of the water, when the pipes will cease to flow, and by the fall of it, when they will begin to run again, you may

safely predict the change ; or you may command them to run or stop, and they will seem to obey your orders.

R E C R E A T I O N XXXII.

The illuminated fountain.

THIS fountain begins to play when certain candles placed round it are lighted, and stops when those candles are extinguished. It is constructed as follows. Provide two cylindrical vessels, A B and C D (Pl. VIII, Fig. 7.) Connect them by four tubes open at both ends, as H I, &c. so that the air may descend out of the higher into the lower vessel. To these tubes fix candlesticks, and to the hollow cover E F, of the lower vessel, fit a small tube K, reaching almost to the bottom of the vessel. At G let there be an aperture with a screw, whereby water may be poured into C D, which when filled must be closed with the screw.

Now

Now, when candles at H, &c. are lighted, the air in the upper cover and contiguous pipes will be thereby rarified, and the jet from the small tube K will begin to play: as the air becomes more rarified, the force of the jet will increase, and it will continue to play till the water in the lower vessel is exhausted. It is evident, that as the motion of the jet is caused by the heat of the candles, if they be extinguished, the fountain must presently stop.

RECREATION XXXIII.

The solar fountain.

THE motion of the water in this fountain is produced by the heat of the sun, in the following manner: G N S (Pl. VIII. Fig. 8.) is a thin hollow globe of copper, of eighteen inches diameter, supported by a small inverted basin, placed on a frame with four legs ABCD, which have between them, at the bottom, a basin of two feet diameter. Through the leg
C

C passes a concealed pipe, which comes from G, the bottom of the inside of the globe: this pipe goes by H V, and joins the upright pipe *u* I, to make a jet as I. The short pipe *u* I, which goes to the bottom of the basin, has a valve at *u* under the horizontal pipe, H V, and another valve at V, above that horizontal pipe, under the cock at K. The use of this cock is to keep the fountain from playing in the day till you think proper. The North pole N of the globe has a screw that opens a hole whereby water is poured into the globe.

The machine being thus prepared, and the globe half filled with water, let it be set in an open place, when the heat of the sun, rarifying the air as it heats the copper, the air will press strongly against the water, which coming down the pipe G C H V I, will lift up the valve at V, and shut the valve at *u*. The cock being opened, the water will spout out at I, and

I and continue to play a long time, if the sun shine.

At night, when the air is condensed, that which is on the outside of the vessel will press on the adjutage I, and shut the valve V ; and at the same time pressing on the water in the basin D u H, which has been played in the day, will push it up, through the valve u, and pipe u H G, into the globe, so as to fill it again to the same height as at first. When the sun shines again on the globe, the fountain will play again, &c. A small jet will play six or eight hours.

If the globe be set to the latitude of the place, and rectified before it be fixed, with the hour lines or meridians drawn upon it, the hours marked, and the countries painted, as on the common globe, it will form a good dial ; the sun then shining upon the same places in this globe, as it
does

does on the earth itself. This fountain was invented by Dr. Defaguliers.

R E C R E A T I O N XXXIV.

The cup of Tantalus.

IN this cup is placed a syphon, the shortest leg of which is near the bottom of the cup, and the longest is concealed in the handle. If water be poured into this cup it will not run out till it come above the top of the bended part of the syphon, and then, by the pressure of the air, it will be forced up the short leg, and run out by that in the handle, till the water in the cup be lower than the short leg of the syphon, which may be placed very near the bottom of the vessel. If the cup be filled just to the top of the syphon, and an apple or orange thrown in, it will, by raising the water, have the same effect as pouring in more.

This

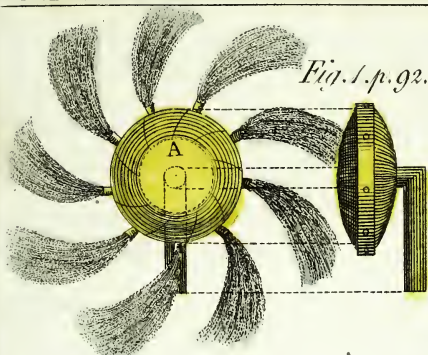
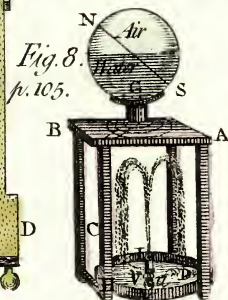
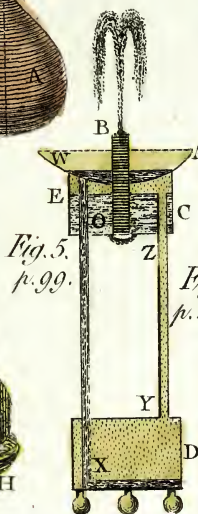
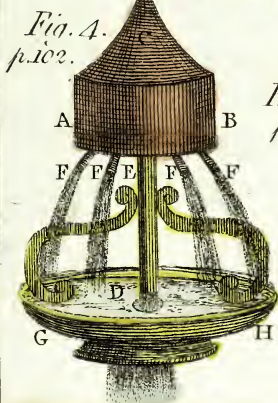
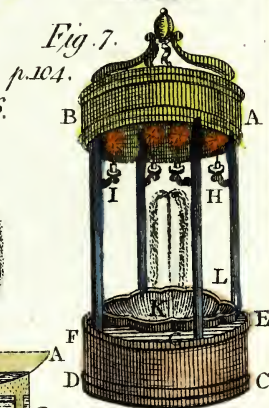


Fig. 2. p. 94.





This is called the cup of Tantalus, from the resemblance of an experiment sometimes made with an image placed upright in the cup, (Pl. IX. Fig. 1.) to the fable of Tantalus. For a syphon being placed in the body of the image, one end of which beginning at the bottom of one foot at A, rises to the upper part of his breast, from thence descends through the other leg, on which he stands, and from thence through the bottom of the cup, into the lower part at B. As soon as the water rises to the chin of the image, above S, it will begin to run out, in the same manner as from the cup above-mentioned.

RECRE-

R E C R E A T I O N XXXV.

The sea gage.

THIS instrument is constructed as follows. A B (Pl. IX. Fig. 2.) is the gage bottle, in which is cemented the gage tube Ff, in the brass cap at G. The upper end of the tube F is hermetically sealed, and the lower, open end f, is immersed in mercury, marked C, on which swims a small surface of treacle. On the top of the bottle is screwed a pipe of brass GH, pierced with several holes, to admit the water into the bottle AB. K is a weight, hanging by its shank L, in a socket N, with a notch on one side at m, in which is fixed the catch l, of the spring s, which passing through the hole L, in the shank of the weight K, prevents its falling out, when once hung on. On the top, in the upper part of the brass tube, at H, is fixed a large empty ball, or full blown bladder

der I, which must be of such a size that the weight K may be able to sink the whole under water.

This instrument is used in the following manner. The weight K is hung on, and the gage being let fall into deep water, sinks to the bottom : the socket N is something longer than the shank L, and therefore, after the weight K comes to the bottom, the gage will continue to descend, till the lower part of the socket strike against the weight : this gives liberty to the catch to fly off the hole L, and let go the weight K. When this is done, the ball or bladder I, instantly buoys up the gage to the top of the water.

While the gage is sinking, the water having free access to the treacle and mercury in the bottle, will, by its pressure, force it up in the tube F f; and the height to which it has been forced by the greatest pressure, which is that at the bottom,

tom, will be shewn by the mark in the tube which the treacle leaves behind it ; and which is here its only use. This shows into what space the whole air in the tube Ff is compressed, and consequently the depth of water, which by its weight produced that compression.

If the gage tube Ff be of glass, a scale may be drawn on it with the point of a diamond, which will shew by inspection, at what height the water stands above the bottom. But the length of ten inches is not sufficient to fathom depths at sea ; for when all the air in such a length of the tube is compressed into half an inch, the depth of water is not more than 634 feet, which is not half a quarter of a mile.

If to remedy this, we use a tube 50 inches long, which for strength, may be a musket barrel, and if the air be compressed into the hundredth part of half an inch, even then the depth will be but 3300 feet, that
is

is 660 feet more than half a mile. But it is reasonable to suppose the cavities of the sea bear a near proportion to the mountainous parts of the land, some of which are more than three miles high. Therefore, to investigate the greatest depths of the sea, the following improvement was made to the foregoing apparatus.

Let B C D F, Fig. 3, be a hollow metal globe, on the top of which is fixed the long tube A B, whose capacity is one-ninth part of the globe. At the lower part D, it has a short tube D E, which is to stand in the mercury and treacle. The air contained in this compound gage-tube is compressed by the water, as before ; but the degree of compression, or height to which the treacle has been forced, cannot here be seen through the tube : therefore, to answer the same end, a slender rod of metal or wood, with a knob at the top of the tube A B, will receive the mark of the treacle, and show it when taken out.

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If

If the tube be 50 inches long, and of such a bore that every inch in length be equal to a cubit inch of air, and the content of the globe and tube together be 500 cubic inches; then if the air be compressed within a hundredth part of the whole, it is evident that the treacle will not approach the top of the tube nearer than five inches, which will answer to the depth of 3300 feet of water, as above. Twice that depth will compress the air into half that space, nearly, that is, two inches and a half, which corresponds to 6600 feet, or a mile and a quarter. Lastly, half that space, or an inch and a quarter, will answer to double the last depth, that is 13,200 feet, or two miles and a half; which is, probably, very near the greatest depth of the sea. This fea-gage was invented by the Drs. Hales and Defaguliers.

R E C R E -

RECREATION XXXVI.

The diving bell.

THERE have been many machines invented to explore the hidden chambers of the deep; as may be easily imagined: for when curiosity is joined by avarice they strongly excite the inventive faculty. Of all those machines the most complete is that invented by Dr. Halley, who does not appear, however, to have been excited by any other motive than curiosity; nor is it wonderful: for to a man of his exalted faculties one motive only is equal to many, when acting conjointly on a vulgar mind.

This machine was in the form of a bell (Pl. IX. Fig. 4.) It was three feet wide at top, five at bottom, and eight feet high, and contained about forty-three cubic feet, or near eight hogshheads.

The machine was coated with lead, and so heavy that it would sink empty. The weight was distributed about the bottom IK, so that it would go down in a perpendicular direction only. In the top was fixed a strong clear glass D, to let in the light from above. There was likewise a cock at B, to let out the hot, foul air. Below was fixed a circular seat LM, for the divers to sit on; and lastly, from the bottom hung, by three ropes, a stage for them to stand on, while they were performing their operations. This machine was suspended from the mast of a ship by a sprit, which was sufficiently secured to the mast-head by stays, and was directed by braces to carry it over board, clear of the side of the ship, and to bring it in again.

To supply the bell with air under water were made two barrels, such as C, of about 63 gallons each; and cased with lead, so that they would sink empty; each of them
had

had a hole in the lower part, to let in the water, as the air in them was condensed in their descent, and to let it out again, when they were drawn up from below.

To a hole in the top of the barrel was fixed a leathern pipe, well prepared with bees-wax and oil; this pipe was long enough to fall below the hole at the bottom, and kept down by a weight hanging to it, so that the air in the upper part, driven there by the encroachment of the water in the descent, could not escape, unless the lower end of the pipe was lifted up.

These air barrels were fitted with tackle adapted to make them rise and fall alternately, like two buckets in a well. In their descent they were directed by lines, fastened at the under edge of the bell, to the man standing on the stage to receive them; who by taking up the ends of the pipes above the surface of the water in the

bell, gave liberty to the water in the barrels to force all the air in the upper parts into the bell, while it entered below and filled the barrels : and as soon as one was discharged, at a signal given, it was drawn up, and the other descended to be ready for use.

As the cold air rushed into the bell from the barrel below, it expelled the hot air through the cock B, at the top of the bell, which was then opened for that purpose. By this method air was communicated so quick, and in such plenty, that the Doctor tells us, he himself was one of five who was at the bottom in nine or ten fathom water, for more than an hour and a half together, without any sort of ill consequence ; and for any thing that appeared to the contrary, he might have continued there as long as he pleased.

In going down, it is necessary the descent should be at first very gentle, that
the

the dense air may be inspired, to keep up by its spring, a balance to the pressure of the air in the bell. At each twelve feet of descent the bell was stopped, and the water that entered was driven out, by letting in three or four barrels of fresh air. By this means, and by taking off the stage, the bottom of the sea could be so far made dry, within the circuit of the bell, as not to be over shoes thereon.

By the glass on the top of the bell so much light entered, when the sun shined, and the sea was clear and even, that Dr. Halley could see distinctly to write and read. By the return of the air barrels he sent up orders, wrote with an iron pen on small pieces of lead, directing where the bell was to be moved. But in dark weather when the sea was rough, the bell would be as dark as night: but then the Doctor observed, he could keep a candle burning in the bell as long as he pleased; for it is found by experiment, that a can-

dle consumes as much air in a minute as a man, that is, about one gallon.

The only inconvenience attending this bell was, that upon first going down, they felt a small pain in their ears, as if the end of a quill was forcibly thrust into them. This pain presently ceased, but on descending lower returned again, and again ceased; and so alternately, 'till the machine got to the bottom, then the air remained of the same density. This inconvenience is supposed to be occasioned by the condensed air shutting up a valve, leading from some cavity in the ear, full of common air; but as the condensed air continues to press harder, it forces the valve to give way, and fills every cavity. One of the divers, thinking to prevent this pressure, stopped his ears with a pledget of paper; which, as the bell descended, was forced so far into his ears, that it was with great difficulty the surgeon could extract it.

This

This bell was so improved by the inventor, that he could detach one of his divers to the distance of a hundred yards from it. For this purpose he contrived a cap or head-piece, something like an inverted hand-basket, as F, with a glass in the fore part, for the diver to see his way,

This cap was of lead, and made to fit quite close about his shoulders : in the top of it was fixed a flexible pipe, communicating with the bell, and by turning a stop-cock near his head-piece, he received air whenever he pleased. There was also another cock at the end of the pipe in the bell, to prevent any accident happening from the person without. This person was well cloathed with thick flannels, which were warmed upon him before he left the bell, and would not suffer the cold water to penetrate ; he was also furnished with a girdle of large leaden weights, and clogs of lead for the feet, which, with
the

the weight of the leaden cap, kept him firm on the ground. His cap contained air enough to serve him a minute or two; then by raising himself above the bell, and turning the cock F, he could replenish it with fresh air. The pipe he coiled round his arm, which served him as a clue to find his way back to the bell.

Since the invention of the above diving machine, there has been one contrived by M. Triewald, F. R. S. and military architect to the King of Sweden, which, for a single person, is in some respects more eligible, and is constructed as follows. AB, (Pl. IX. Fig. 5.) is the bell, which is sunk by lead weights DD, hung to its bottom. This bell is of copper, and tinned all over on the inside, which is illuminated by three strong convex lenses G, G, G, with copper lids H, H, H, to defend them. The iron ring or plate E, serves the diver to stand on when he is at work, and is suspended at such a distance from the
bottom

bottom of the bell, by the chains F, F, F, that when the diver stands upright, his head is just above the water in the bell, where the air is much better than higher up, because it is colder, and consequently more fit for respiration. But as the diver must be sometimes entirely within the bell, and his head of course in the upper part, the inventor contrived, that even there, when he has breathed the hot air, as long as he well can, he may, by means of a spiral copper tube C placed close to the inside of the bell, draw the cooler and fresher air from the lowermost parts ; for which purpose a flexible leather tube, about two feet long, is fixed by one end to the upper part of the copper tube ; and to the other end is fixed an ivory mouth-piece, by which the diver respire the air from below.

P Y R O-

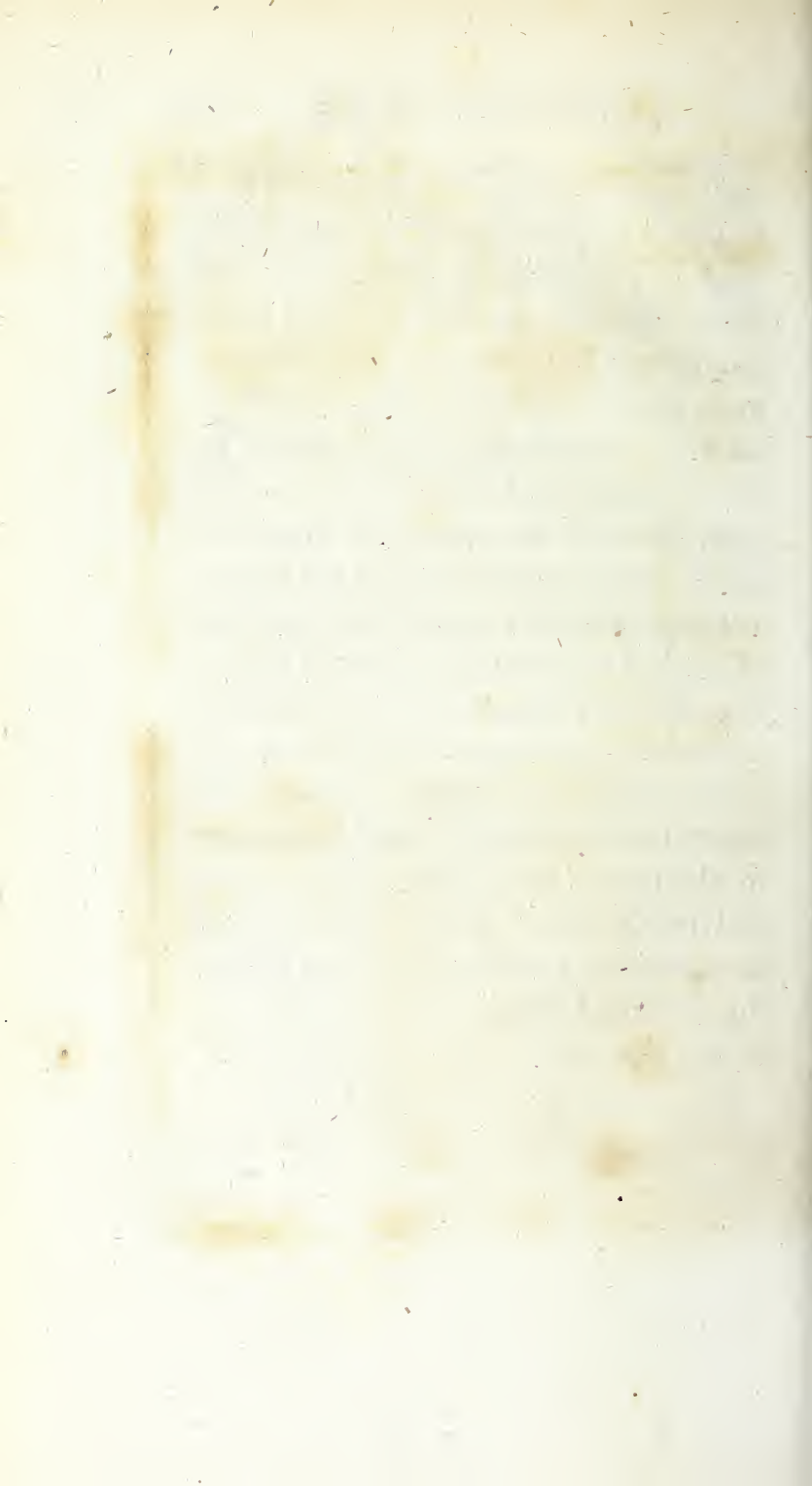


Fig. 1. p. 109.

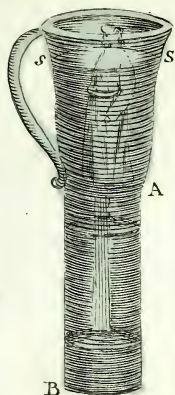


Fig. 3.
p. 113.

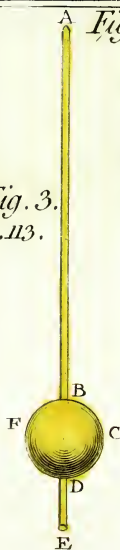


Fig. 2. p. 110.

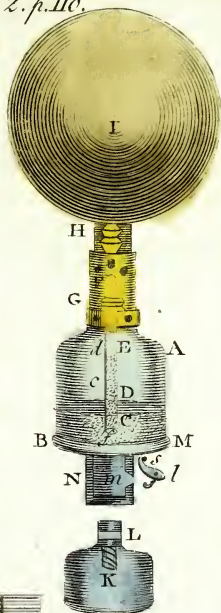
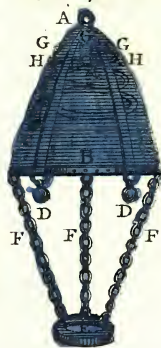


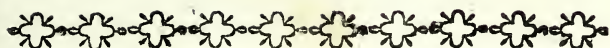
Fig. 4. p. 115.



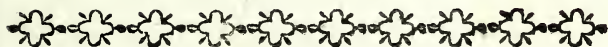
Fig. 5. p. 123.







PYROTECHNICS.





P Y R O T E C H N I C S.

DEFINITIONS.

1. **P**YROTECHNICS, is that branch of phyfiology which explains the nature of fire, and the manner of employing it in offices of ufe or pleafure.
2. Fire is faid to be of fix degrees.
3. The first degree of fire is that meafured by Farenheit's thermometer between its first and 80th degree ; and is the limit neceffary to vegetation.
4. The fecond degree of fire, is that contained between the 40th and 94th degrees of the fame thermometer : and is that neceffary to animal life.
5. The third degree of heat extends from the 94th to the 212th degree of that thermo-

thermometer ; the last of which is commonly that of boiling water.

6. The fourth degree of heat is extended to the 600 degree of the same thermometer ; which is very near the boiling point of mercury : within this degree lead and tin melt*.

7. The fifth degree of heat is that in which all metals and fixed salts melt, and most other bodies vitrify or become volatile. This is the extreme heat of a chemical furnace.

8. The sixth degree of heat is that of the focus of a large lens or mirror, which no substance can sustain unaltered.

9. Heat is divided into absolute and relative : absolute heat is that which exists in any substance : and relative or comparative heat is that which is perceived by an animal body.

* These divisions of heat by the thermometer, were first fixed by the illustrious Boerhaave.

APHORISMS.

1. Absolute heat proceeds from an intestine motion in the parts of any body*.

2. Relative heat arises from the degree of intestine motion in any substance being greater than that of the animal body to which it is applied.

3. There is the same affinity between absolute and relative heat, as between motion and velocity : absolute heat being the whole motion of all the parts of the heated body, and relative heat only the comparative velocity of the parts †.

* This is the doctrine of fire maintained by the English philosophers : those of other nations assert, in general, that fire is an element, like air and water, that it is contained in all bodies, and obtainable from them by attrition or pulsation.

† This is exemplified by placing equal quantities of mercury and water over a sand heat, where the fire being uniformly communicated to each of them, they will acquire, in the same time, the same degree of absolute heat : but the relative heat, or that that is sensible to an animal body, will be near

4. When the motion of the parts of an inflammable body is increased to a certain degree, it will throw off a quantity of particles, in form of smoke. If the velocity be further increased, those particles will become sparks of fire : and if the velocity be still further increased, those particles will make a body of fire, in the form of a flame.

5. The effect of fire in burning proceeds from the velocity of its particles, which so far increase the velocity of those of the body to which it is applied, as to separate them from the body, and drive them beyond the sphere of its attraction. By which mean the body is dissolved, such of its particles as are volatile fly off in smoke or flame, and the rest remain in the form of a calx or ashes.

6. The force or burning power of the

fourteen times greater in the water than the mercury ; for the water having fourteen times less matter, will have acquired a velocity, in proportion as much greater.

parti-

particles of fire when condensed, as in the focus of a lens or mirror, are increased in proportion to the area of the glass, directly, and the square of the focal distance, inversely*.

7. The forcing of heat increases in proportion to the squares of the distances, inversely; that is at the distance of one foot the fire is four times as strong as at two feet, and nine times as strong as at three feet; and so in proportion.

8. The dimensions of bodies in general, are increased by heat †.

* For example: suppose the area of one glass be to twelve square inches, and its focal distance nine inches; and the area of another to be ten inches, and its focal distance five inches. Then the burning power of the former will be to the latter as 12 multiplied by 25, is to 10 multiplied by 81; that is, as 300 to 810, or as 30 to 81.

† Dr. Halley found that water has no perceptible expansion when gently heated, but when boiled, expands one twenty-sixth part. Mercury with a very gentle heat expands one-seventy-fourth part, and spirit of wine, with a heat much less than that of boiling water, expands one-twelfth.

9. Fire pervades, and is found in all bodies.

10. The immediate inflammable matter of every body is oil, or an unctuous substance.

11. No substance will continue to burn without the admission of fresh air.

12. Fire acts in all directions from the ignited body, as from a center.

M. Musshenbroek found the expansions of the following metals in the same heat, to be in the proportions here set down. Silver 78 ; iron 80 ; steel 85 ; copper 89 ; brass 110 ; tin 153 ; lead 155.

R E C R E -

RECREATION XXXVII.

The inflammable phosphorus.*

TAKE the meal or flour of any vegetable, put it into an iron pan over a moderate fire, and keep it stirring with an iron spatula, till it be converted into a black powder: to one part of this add four parts of crude alum. Make the whole into a fine powder, which, being put into an iron pan over the fire, is to be kept constantly stirring with a spatula till almost ignited, to prevent its cohering in lumps, as it is apt to do upon the melting of the alum, in which case it must be broke again, stirred about, and accurately mixed with the flour, till it emit no more fumes, and the whole appear a fine, dry, black, fixed powder.

* For a more easy method of preparing a lucid phosphorus, see Vol. III. p. 91.

Put this powder in a clear, dry phial, with a narrow neck, filling to about one-third from the top. Then stop the mouth of the phial with loose paper, so as to let the air pass freely through it, and leave room for fumes to come thro' the neck. Place the phial in a crucible, encompassed on all sides with sand, but so that it may not touch any part either of the bottom or sides of the crucible, but a considerable space be every where left between them. The phial must be covered up with sand, so as only to leave a part of it bare, through which you may perceive whether the matter be ignited. In this state the crucible is to be surrounded with coals kindled slowly, till it be well heated on all sides, when the fire is to be raised, till the crucible, sand, gravel, glass and matter in it, be red hot; in which state they are to be kept for an hour; after this the fire being still kept up, the orifice of the phial is to be well closed with wax, to prevent any air from entering. Thus
the

the whole being left to cool undisturbed, you will at last find in the phial a black dusty coal, formed of the flour and alum.

A small quantity of the matter contained in this phial being shook out, into the cold air, immediately takes fire and burns ; but having once felt the air, loses all power of kindling thereby. This manner of producing fire appears the most extraordinary of all that have hitherto been discovered, since the matter thus prepared will preserve its virtue three months, provided the air be kept from it : but if the smallest quantity of moisture, even of that little which is lodged in the air, come to touch this powder, the experiment will not succeed.

RECREATION XXXVIII.

The liquid phosphorus.

TAKE a piece of English phosphorus, about the size of a pea, and cutting it very small, put it into half a glass of quite clear water. Boil it in a little earthen vessel over a moderate fire. Have a phial with a narrow neck and a glass stopper; take out the stopper and plunge the phial in boiling water: then take it out, and pouring out the water, put the boiling mixture immediately into it: instantly stop the phial, and cover it with a cement, that the air may not in any degree enter it.

This mixture will shine in the dark for several months, though the phial be not touched: if it be shook, especially in warm, dry weather, very strong lightnings will dart from the middle of the water.

Some

Some pleasing amusements may be produced by putting this phosphorus in a long or broad phial, and pasting a paper over it, in which letters or figures are cut.

R E C R E A T I O N XXXIX.

The fulminating gold.

PLACE a small mattrafs, on a sand heat, and in it put one part of filings of pure gold and three parts of aqua regia. When the liquor has entirely dissolved the gold, put the mixture in a phial, and add five or six times as much common water

Then take spirit of sal ammoniac, or oil of tartar, and pour it, drop by drop, on the dissolution till the ebullition cease. Let this mixture rest, till the gold be entirely precipitated to the bottom of the phial. Pour the water that swims at the top gently off, and after washing this gold

gold duſt ſeveral times in common water, dry it by a very moderate heat, by putting it on a paper that will abſorbe all its moiſture.

If a grain of this powder be put in a copper ſpoon, over the flame of a candle, as ſoon as it is well heated, it will go off with a report like that of a piſtol. If the ſpoon be not ſufficiently ſtrong, the matter will run through it, and make an exploſion underneath, with great violence.

R E C R E A T I O N XL.

The burning fountain.

MAKE a veſſel of tin or copper, as A B C D, (Pl. X. Fig. II.) or of what other form you pleaſe, Let there be an eolipile E, of the ſame metal, and of the ſize and figure of a pear, and let its neck paſs through the top of the veſſel where it ſhould not be of more than one quarter of an inch diameter; to this neck
join.

join the pipe F, whose bore at the extremity should be extremely small, and there must be a small cock at G, that goes across it. Pour some spirit of wine into the eolipile, and having filled the vessel with boiling water, cover it over.

The heat of the boiling water rarifying the air contained in the eolipile, it will press on the surface of the spirit of wine, and force it through the small hole at the end of the pipe. Therefore if the flame of a candle be placed close to the orifice of the pipe, the spirit will take fire, and it will form a flaming fountain, that will have a pleasing effect; and if the orifice of the pipe be quite small will continue for some time.

This piece may be executed on a larger plan, and many of the jets described under the article of Hydraulics, may be annexed to the eolipile; taking care always that the orifice by which the spirit is to pass
be

be extremely small. If filings of iron be sifted over these jets, through a very fine sieve, they will take fire, and imitate exactly the appearance of fireworks.

RECREATION XLI.

Prince Rupert's drop.

TAKE up a small quantity of the melted matter of glass, with a tube, and let a drop fall into a pail of water, by which it will retain its form, and appear solid throughout: except that it contain a few air bubbles. This drop will have a small tail, which being broke the whole substance of the drop will burst, with great violence, into a fine powder; and give a little pain, but do no hurt to the hand that breaks it.

It is remarkable, that the bulb or body will bear the stroke of a hammer without breaking, but if the tail be broke, the abovementioned effect is produced.

duced. If the drop be cooled in the air, it will not produce the effect; and if it be ground away on a stone, nothing extraordinary appears. But if it be put into the receiver of an air pump, and there broke, the effect will be so violent as to produce light.

This phenomenon is supposed to proceed from the particles of the glass being in a state of repulsion, while melted, but by being dropped into cold water, the external particles are condensed, and hold the internal, which are still in a state of repulsion, as in a case; but when an opening is made in that case, by breaking off the tail, the confined particles rush forth, and burst the drop with the greatest violence.

R E C R E A T I O N XLII.

The revived rose.

TAKE a rose that is quite faded, and throwing some common sulphur on a chafingdish of hot coals, hold the rose over the fumes, and it will become quite white. Then dip it in a basin of water, and giving it to any one, tell him to put it in his box or drawer, and after locking it, to give you the key. When you return him the key five or six hours after, and he unlocks his drawer, instead of the white rose he puts in it, he will find one that is perfectly red.

R E C R E-

RECREATION XLIII.

Writing on glass by the rays of the sun.

DISSOLVE chalk in aqua fortis, to the consistence of milk, and add to that a strong dissolution of silver. Keep this liquor in a glass decanter well stopp'd. Then cut out from a paper the letters you would have appear, and paste the paper on the decanter, which you are to place in the sun, in such a manner that its rays may pass through the spaces cut out of the paper, and fall on the surface of the liquor. The part of the glass thro' which the rays pass will turn black, and that under the paper will remain white. You must observe not to move the bottle during the time of the operation.

RECRE-

RECREATION XLIV.

The magic picture,

TAKE two pieces of glass about three inches long and four wide : they must be quite level, and exactly of the same size. Place them one over the other, and let there be about one-twentieth part of an inch between them, which you may effect by pasting papers on their four corners. Join these two glasses together by a luting composed of lime slacked by lying in the air and reduced to very fine powder, mixed with the white of an egg. Cover all the borders of these glasses with parchment or bladder, except a small opening left on one side, in order to introduce the following composition.

Dissolve by a slow fire six ounces of fine hogs-lard, and put to it half an ounce of white wax, and if you find it necessary to render it more sensible to the heat, add
an

an ounce, or more of the clearest linseed oil. This, when liquid, is to be poured between the glasses by the space left in their sides, and which you are then to stop close up. Wipe the glasses clean and hold them before the fire, to see that the composition will not run out at any part. Then paste a picture, painted on any thin substance, or a coloured print, with its face to one of the glasses, and fix the whole in a frame.

The mixture between the glasses, while it is cold, will quite conceal the picture, but becoming perfectly transparent by heat, the painting will appear as if there was only a single glass before it. As the composition cools, the picture will gradually disappear, and at last be quite invisible.

R E C R E A T I O N XLV.

The luminous oracle.

PROCURE a tin box ABCD, (Pl. XII. Fig. 1.) about eight inches high, four wide, and two deep, and let it be fixed on the wooden stand E. On two of the insides let there be a groove FG, and in the front an opening I, three inches wide and one high.

At the back of the box let there be a little tin door, that opens outward, by which two wax candles M, may be put in. Let the top of the box have a cover N, of the same metal, in which there are several holes, and which may be taken off at pleasure.

Provide a double glass OP, Fig. 2. constructed in the same manner as that in the last Recreation. On one of its sides you are to paste a black paper, the length of which

which is to be divided into three parts, and the breadth into fifteen : in every two of these fifteen divisions you cut out letters, which will make in the whole three answers, to three questions that may be proposed. On the other side of the glass paste a very thin paper, and to the top fasten a small cord, by which they may be made to rise or descend in the groove F G.

Then take a slip of pasteboard R S, Fig. 3. one inch and a half wide and three inches long, which is to be divided into fifteen equal parts, similar to those of the paper O P, and cut out spaces, as in the figure, so that this paper, sliding horizontally before O P, will either cover or conceal the letters cut in that.

This pasteboard is to slide between two brass wires, and is to be fastened to one side of the box, by a string that communicates with a small brass spring, and to

the other side, by a string fastened to the box by a small piece of wax, so situate that the string may be easily set at liberty by the heat of the candles placed in the box.

Take a parcel of cards, and write on them different questions, three of which are to correspond with the answers on the glass. Shuffle these cards, and let a person draw any one of the three questions. Then by raising the glass you bring the answer against the hole in the front of the box. You next place the candles in the box, the heat of which will melt the wax that holds the paper R S, which being then drawn by the spring the answer will be visible, and in proportion as the composition between the glasses becomes diluted, by the increase of the heat, the letters will become more strongly illuminated.

The

The letters cut in the paper may be made to answer several different questions, as has been explained in other Recreations : and the whole parcel of cards may consist of questions that may be answered by one or other of the three divisions in the paper.

RECREATION XLVI.

To produce the appearance of a flower from its ashes.

MAKE a tin box ABCD, Plate XII. Fig. 4.) with a cover M, that takes off. Let this box be supported by the pedestal FGHI, of the same metal, and on which there is a little door L. In the front of this box is to be a glass, O.

In a groove, at a small distance from O, place a double glass of the same sort with that in the last Recreation. Between the front and back glasses place a small upright

L 3 tin

tin tube, supported by the cross-piece R. let there be also a small chafing-dish placed in the pedestal FGHI. The box is to be open behind. You privately place a flower in the tin tube R*, and presenting one that resembles it to any person †, desire him to burn it on the coals in the chafingdish.

You then strew some powder over the coals, which may be supposed to aid the ashes in producing the flower; and then put the chafingdish in the pedestal, under the box. As the heat by degrees melts the composition between the glasses, the

* This flower must not be placed so near the front glass, as to make it in the least degree visible.

† You may present several flowers, and let the person choose any one of them. In this case while he is burning the flower, you fetch the box from another apartment, and at the same time put in a corresponding flower, which will make the experiment still more surprising.

flower

flower will gradually appear, but when the chafingdish is taken away, and the power of the ashes is supposed to be removed, the flower soon disappears.

RECREATION XLVII.

To produce fire by the mixture of two cold liquors.

TAKE half a pound of pure dry nitre, reduced to powder, put it in a retort that is quite dry, add to it an equal quantity of oil of vitriol highly rectified, and distilling the mixture in a moderate sand heat, it will yield a liquor in form of a yellowish fume, which being caught in a clean dry receiver, is the *Spiritus nitri Glauberianus*. Now if to a dram of distilled oil of cloves, saffrafas, turpentine, or caraways, contained in a glass vessel, there be added an equal quantity or half as much more, of the above spirit, though both the bodies are perfectly cold before

L 4

the

the mixture, a violent flame will instantly arise, and destroy them, leaving only a little resinous mater at the bottom.

R E C R E A T I O N XLVIII.

Artificial lightning.

PROVIDE a tin tube that is much larger on one side than the other, and in which there are several holes. Fill this tube with rosin in powder, and when it is shook over the flame of a torch, it will produce a sudden coruscation, that strongly represents a flash of lightning. You are to observe that it is not the flame itself that is to be seen, but its reflection, as is practised at the theatres, and as happens, for the most part, in nature*.

* It is after this manner that the flambeaux of the furies on the stage are constructed, except that at the end of each of them there is a match, dipped in spirit of wine, by means of which it is only necessary to shake them, and they will produce a sudden and very considerable flame.

R E C R E-

RECREATION XLIX.

Artificial thunder.

TAKE a strong bottle that holds about a quarter of a pint, in which put one ounce of concentrated spirit of vitriol, and adding to that two drachms of the filings of iron, stop the bottle close. After a short time shake the bottle, and taking out the cork, put a lighted candle near the mouth of it, which should be a little inclined, and there will presently arise an inflammation, attended with a loud noise.

If you are apprehensive of any mischievous effects from the bursting of the bottle, you may surround it with a strong cloth: or you may put it on the ground and light the vapour by a bougie fixed to the end of a long stick.

Another way of imitating thunder is by mixing three parts of saltpetre, two parts

parts of salt of tartar, and two parts of sulphur, and putting the quantity of a small nut in an iron ladle or shovel, place it over a coal fire. The explosion of this mixture will much resemble a moderate clap of thunder.

If you would produce a more violent explosion, put an ounce or two of this mixture in the shovel, but then you must have a chafingdish of hot coals, and placing it out of the house, stand at a considerable distance from it, and not go near it, till the matter be completely exploded, or what is better, till the fire be out. Experiments of this nature should, in general be conducted with great caution, for an amusement of this kind would be dearly bought with a wound in the face, or the loss of sight.

RECRE-

RECREATION L.

The predicted earthquake and volcano.

GRIND fresh iron filings, free from rust, with an equal quantity of pure sulphur, for a long time, till the whole be formed into a fine powder. This mixture kept in a dry air will continue cold for any time, but if it be wrought up with only as much fair water as will form it into a stiff paste, the mass will soon grow warm, swell, heave, emit a thick smoke, and at last a sulphureous fire and flame. Therefore take about fifty pounds of the above powder, and, burying it privately about a foot deep under the earth, you may safely predict that in about eight hours time the ground will begin to heave and swell, that it will send forth hot sulphureous steams, and at last, bursting into live flames, will form a true volcano.

The

The pretended miracles of Mahomet and Haly, were, as Boerhaave observes on a similar instance, mere trifles to this. If any leader of a sect, a very few centuries past, had been in possession of this secret, and had performed this miracle in confirmation of his doctrine, the man who had dared to disbelieve it would have been regarded as a very hardened infidel indeed !

We shall here add the description of a new method of imitating artificial fireworks, which appears to be the invention of the ingenious M. Guiot.

To perform these recreations to the greatest advantage, there are three circumstances to be carefully observed : the first is, the different colours of the fire : the second, is the manner of cutting out the several figures, and the third, the direction of the motion of each piece, whether it be swift or slow, strait or circular.

Arti-

Artificial fireworks may be reduced to four principal colours. The first is that of jets of fire, which is of a clear white : the second is that of such jets as are of a yellow or gold colour : the third is that of serpents or rockets, which is very bright, and of a light blue cast* : and the fourth is that of a colour inclining to red, and is commonly used in cascades of fire.

The vivacity of fire being imitated, by the rays of light that fall upon transparent paper †, as we shall show hereafter, the paper is to be stained with different colours. For the first sort of fire it is left of its natural colour : for the second an infusion of saffron may be used, made more or less strong : for the third a light tincture of Prussian blue : and for the

* There is another sort of fire of a stronger blue, of which cyphers and emblems are formed, and which is placed on the centers of suns.

† The paper should be quite thin, and after it is coloured, may be made more transparent by being dipped in, or rubbed over with clear oil.

fourth

fourth, a small quantity of carmine may be put in the saffron water just mentioned.

If among these fireworks you would have some parts that are transparent, and thro' which other parts are to be seen, you must use for the transparent parts a paper that is thicker than the other, that the latter may appear with a due degree of superior lustre: for in these exhibitions it is from a just mixture of light and shade that the most pleasing effects are produced.

R E C R E A T I O N L I.

To imitate a jet de feu, column, globe, or pyramid of fire.

TAKE a paper that is blacked on both sides*, and of a proper size for the figure you intend to exhibit, for example,

* Instead of black, the paper may be coloured on each side with a deep blue, which will be still better for such as are to be seen through transparent papers.

that

that of Fig. 1, or 2. Plate X. In this paper cut out with a penknife several spaces B, beginning from the point A; and with a piercer make a great number of holes, rather long than round, and at no regular distance from each other: observing, however, that they must form right lines from the point A, as is clearly expressed in the figures, the parts engraved being those that are to be cut out.

To represent revolving pyramids and globes, such as Fig. 3, and 4. the paper must be cut through with a penknife, and the space cut out between each spiral should be three or four times as wide as the spirals themselves. You must observe to cut them in the same form represented in the figures, that the pyramid or globe may appear to turn on its axis. The columns that are represented in pieces of architecture, or in jets of fire, must be cut in the same manner, if they are to be represented as turning on their axes.

In

In like manner may be exhibited a great variety of ornaments, cyphers, and medallions, which, when properly coloured, cannot fail of producing a most pleasing effect*.

When these pieces are drawn on a large scale, the architecture or ornaments may be shaded; and to represent different shades, pieces of coloured paper must be pasted over each other, which will produce an effect that would not be expected from transparent paintings. Five or six pieces of paper pasted over each other will be sufficient to represent the strongest shades.

To give these pieces the different motions they require, you must first consider the nature of each piece: if, for example you have cut out the figure of the sun, as plate X. Fig. 5. or of a star as Fig. 6.

* There should not be a very great diversity of colours, as that would not produce the most agreeable appearance.

you

you must construct a wire wheel of the same diameter with those pieces, in the manner represented in Fig. 7.* over this wheel you paste a very thin paper, on which is drawn, with thick black ink, the spiral figure represented by Fig. 8. The wheel thus prepared, is to be placed behind the sun or star, in such manner that its axis may be exactly opposite the center of either of those figures. This wheel may be turned by any method you think proper.

Now, the wheel being placed directly behind the sun, for example, and very near to it, is to be turned regularly round, and strongly illuminated by candles placed behind it. The lines that form the spiral will then appear, through the spaces cut out from the sun, to proceed from its center to its circumference, and will re-

* This wheel is made of wire, that its radii, by being small, may not intercept the light that is to be placed behind it.

semble sparks of fire that incessantly succeed each other. The same effect will be produced by the star, or by any other figure where the fire is not to appear as proceeding from the circumference of the center.

These two pieces, as well as those that follow, may be of any size, provided you observe the proportion between the parts of the figure and the spiral, which must be wider in larger figures than in small. If the sun, for example, have from six to twelve inches diameter, the width of the strokes that form the spiral need not be more than one-twentieth part of an inch, and the spaces between them, that form the transparent parts, about two-tenths of an inch. If the sun be two feet diameter, the strokes should be one-eighth of an inch, and the space between one quarter of an inch ; and if the figure be six feet diameter, the strokes should be one quarter of an inch, and the spaces five-twelfths of an

an inch. These pieces have a pleasing effect when represented of a small size, but the deception is more striking when they are of large dimensions.

It will be proper to place these pieces, when of a small size, in a box quite close on every side, that none of the light may be diffused in the chamber : for which purpose it will be convenient to have a tin door behind the box, to which the candlesticks may be foldered, and the candles more easily lighted.

The several figures cut out should be placed in frames, that they may be put, alternately, in a groove in the fore part of the box : or there may be two grooves, that the second piece may be put in before the first is taken out. The wheel must be carefully concealed from the eye of the spectator.

Where there is an opportunity of representing these artificial fires by a hole made in a partition, they will doubtless have a much more striking effect, as the spectator cannot then conjecture by what means they are produced.

To represent fires that flow from the circumference to the center, as B B, &c. (Pl. X. Fig. 9.) and at the same time others that flow from the center to the circumference, as A, A, &c. you must construct the double spiral represented by the 10th figure of the same plate.

When this wheel is placed behind Fig. 9, the concentric spiral A, Fig. 10. being opposite the parts A, Fig. 9. the fire will appear to issue from the center, as before : but the parts against the ex-centric spiral of the wheel B, Fig. 10. which are those marked B, in Fig. 9. will
appear

Fig. 1. p 159.



Fig. 2. p 159.



Fig. 5. p 160.

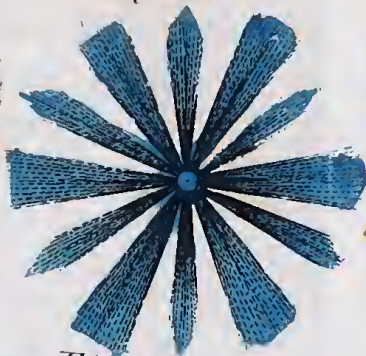


Fig. 6. p 160.



Fig. 8. p 161.



Fig. 7. p 161.



Fig. 9. p 164.

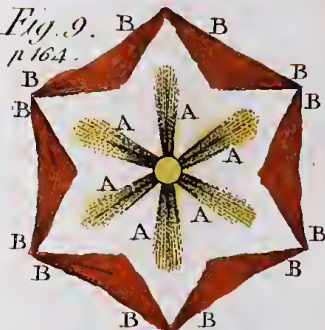


Fig. 3. p 159.



Fig. 10. p 164.



Fig. 11. p 138.

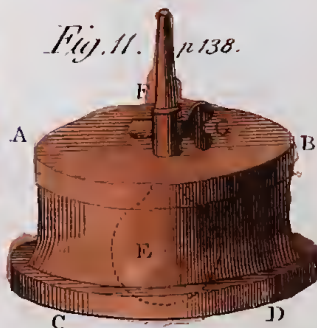


Fig. 4. p 159.





appear to move from the circumference to the center.

It is easy to conceive that by extending this method, wheels may be constructed with three or four spirals, to which may be given different directions, as in Plate XI. Fig. 1. where is drawn, on the transparent piece, the spirals that are proper to produce, not only jets de feu, but also small pyramids, as A, A, &c. which will appear to turn on their centers. It is manifest also, that on the same principle, a great variety of transparent figures may be contrived, and which may be all placed before the same spiral lines.

R E C R E A T I O N LII.

To represent cascades of fire.

IN cutting out cascades you must take care to preserve a natural inequality in the parts cut out, as is expressed in Plate XI. Fig 3. for if to save time, you should make all the holes with the same pointed tool, the uniformity of the parts will not fail to produce a disagreeable effect. As these cascades are very pleasing when well executed, so they are highly disgusting when imperfect. These are the most difficult pieces to cut out.

To produce the apparent motion of these cascades, instead of drawing a spiral, you must have a slip of strong paper as ABCD, (Pl. XI. Fig. 2.) of such length as you judge convenient. In this paper there must be a great number of holes near each other, and made with pointed tools of different dimensions.

At

At each end of the paper a part, of the same size with the cascade, must be left uncut : and towards those parts the holes must be made at a greater distance from each other, as is expressed in the figure. This paper is to be fixed by its two extremities, to the two rollers A and B, Fig. 3.

When the cascade that is cut out is placed before the scroll of paper just mentioned, and it is entirely wound upon the roller A, the part of the paper that is then between E and B, being quite opaque, no part of the cascade will be visible. But as the winch D is turned gently and regularly round, the transparent part of the paper proceeding from A to B, will give to the cascade the appearance of fire that descends in the same direction ; and the illusion will be so strong that the spectators will think they see a cascade of fire : especially if the figure be judiciously cut out.

A cascade may be also tolerably well executed by a spiral, in the manner expressed in Fig. 4 : but the roller is more eligible. The paper being totally rolled on B, the part between A and B will be quite opaque : therefore the cascade may be then taken away, and another piece, which represents fire that ascends, as a jet, may be placed in its room : and thus the pieces may be alternately, and continually changed.

RECREATION LIII.

Imitative illuminations.

ON a very strong, double paper, whose backside is blacked with soot, dissolved in brandy, and to which a little gum arabic is added, you must first paint the draught of the illumination you intend to represent in miniature, and mark the exact place of the several lamps and other parts that compose it. Then take piercers of different sizes, with which make holes
in

Fig. 1. p 165.

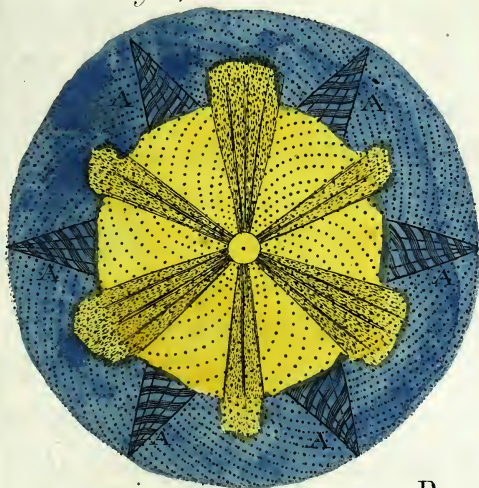


Fig. 2. p 166.



Fig. 3. p 166.

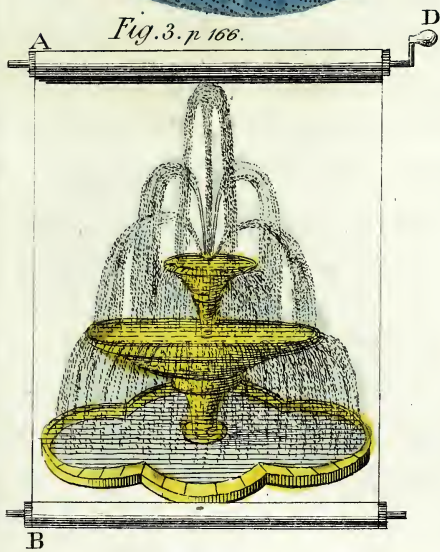
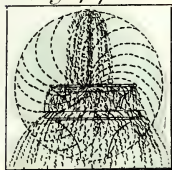


Fig. 4. p 168.





in the papers, in such form as shall represent the flame of a lamp or other body. If the lamps are supposed to be all in a line, you must use the finest piercers for the smallest lamps, and the larger for the greatest: but if the parts of the illumination be supposed at different distances, then the fine piercers are to be used for those parts that are most distant, and the holes must be nearer together, in proportion to the distance. If there be objects in front perpendicular to the point of view, you must use piercers whose diameters decrease insensibly, and make the holes continually closer, in proportion as the extremities of the front are more distant. It is not material, in this case, whether the points be close together, provided the perspective be observed.

When the piece is completely cut out, you place behind this double paper one that is very thin; observing to colour the parts that are to appear the most distant
with

with a little carmine diluted in water*. It is then to be placed in a box, and strongly illuminated behind by several candles or lamps placed at equal distances from each other, that all the parts may be equally illuminated †: for otherwise the illusion will not be complete. The front of the paper should be also illuminated with a faint light, such as is just sufficient to show the pieces of architecture that may be painted on it.

After the manner above described, prints also of every kind, may be cut out, and placed in any optical machine, except such as have an inclined mirror, for there the print being naturally placed

* This circumstance is necessary, for the more distant natural illuminations are, the more red they appear.

† The candles should be placed not close to the paper, but at five or six inches distance, and if they do not produce a light sufficiently strong, you may place more. It will be proper to line the box with tin, as that will reflect the light on the piece.
in

in a horizontal direction, it will be difficult to illuminate it sufficiently to produce any remarkable effect. If you are desirous, however, of making an experiment with a print in a horizontal position, instead of placing a transparent paper behind it, you must put one that is gilt, which is to appear through the parts cut out. A print thus prepared, when a strong light is thrown upon it, will represent an illumination tolerably well.

APPEN-

A P P E N D I X.

Several of the Recreations in this Appendix have, in fact, but little relation to experimental philosophy, especially those that depend on a dexterous manœuvre ; but as experiments of this kind are commonly found in books of mathematical recreations, it seemed requisite to insert some of the most entertaining among them at the end of this treatise.



CHYMICAL TRANSMUTATIONS.

AMONG the most pleasing as well as surprising phenomena of nature, may be justly ranked the transmutations produced by chymistry, especially those of colours ; and recreations of this kind are the more pleasing, as they are, for the most part, easily executed.

RECREATION LIV.

Transcolourations.

TAKE antimony and grind it to a powder, and it will become black. Let it be calcined with aqua regia, and it will be of a greenish yellow ; white, red, yellow, greenish, and black, when sublimed with sal ammoniac ; of an uniform red, when freed from its salt by water ; but white when fixed with thrice its weight of nitre. Thus you have almost all the colours in one solid body. Mercury dissolved

solved by aqua fortis, and distilled in a glass retort, affords likewise, in different parts of the glass, a variety of colours.

To make a gold colour by mixing a limpid liquor with a grey powder : pour hot alcohol on sulphur, melted with fixed alkali, then ground and heated. To change this gold coloured liquor into one of the colour of milk, by pouring it into a clean glass : let the glass be previously rinsed with oil of vitriol.

To turn an almost limpid liquor blue : pour spirit of sal ammoniac to a solution of verdigrease in vinegar, and dilute it with water till it be almost limpid. To turn that blue liquor pellucid, add acid to it, till the acid predominate.

To turn a very green liquor of a beautiful violet colour : to a high green solution of copper in vinegar, drop spirit
of

of small ammoniac, till the alkali predominate.

To turn a blue into a beautiful green.
To a rich solution of copper in spirit of fal ammoniac, add vinegar, or any other acid, till the acid preponderate.

To produce numerous blues and greens, between a deep blue and a deep green: put a strong and hot solution of copper in fal ammoniac, into a clean cylindrical glass, and add thereto, slowly, spirit of nitre, drop by drop. A different colour, between the two degrees, will appear upon the addition of each other.

R E C R E A T I O N LV.

To make a colourless liquor black, by pouring it into a clean glass.

RINSE a clean hot glass in a strong solution of the vitriol of iron ; then pour out into a warm infusion of bruised white galls in fair water, made so weak as scarce to afford any colour. This black mixture is instantly made. Instead of galls you may use red roses, pomegranate bark, or tea, sage, or oak leaves.

R E C R E A T I O N LVI.

To turn a pellucid liquor black, by adding to it a white powder.

PUT a hot weak pellucid infusion of galls into a glass, throw into it a grain of the vitriol of iron calcined to whiteness, and heated : this, as it falls, makes a black cloud, that diffuses itself
through

through the transparent liquor in a pleasing manner, and gradually turns it black all round.

The same may be done with a pellucid drop: by putting a single drop of the aqueous solution of the vitriol of iron into the hot solution of galls.

The same effect may also be produced by the addition of a little yellow or red powder; in the first instance by using vitriol calcined to a yellow colour; and in the other, by the colcothar of vitriol calcined to redness. To produce the same effect by a drop of gold coloured liquor, use the golden tincture made with the red calx of the vitriol of iron, and the dulcified spirit of salt.

In all these experiments, while the liquor is changing from limpid to deep black, there arise almost innumerable

N 2

shades,

shades, or intermediate degrees of darkness, which at last all terminate in black.

The black liquor produced in all the preceding cases, may be rendered pellucid again, by pouring the liquor hot into a glass rinsed with the pure oil of vitriol, which attracts the iron. But the black liquor made with the calx of iron remains somewhat reddish, while it tends to transparency.

To make this transparent liquor black again, pour to it as much hot oil of tartar per deliquium, as will saturate the acid that has attracted the metallic matter. This is attended with an effervescence, which at the same time reduces, destroys, and regenerates, vicissitudes of colours, which is best perceived by letting the alkaline liquor fall in at several times, but with a quick motion.

Lastly,

Lastly, if a sufficient quantity of acid be added to the black liquor thus regenerated, so as to abolish the alkali, the whole will become pellucid again; and this blackness may be reciprocally destroyed or restored. Hence also appears the surprising power of a metal to produce blackness, and how little matter is required to the production of colours.

RECREATION LVII.

To produce different colours by pouring a limpid liquor in a clean glass.

TAKE a strong solution of mercury made with spirit of nitre; dilute it with water, and pour it into a hot glass rinsed in a strong spirit of sea salt, and it will become coloured. A very dilute solution of silver, made in spirit of nitre poured into a glass prepared in the manner just mentioned, or the oil of antimony poured into a glass rinsed in hot water, will have the same effect.

To produce an orange colour, pour hot water upon new made crocusmettallorum, and put it into a clean glass rinsed with any acid.

R E C R E A T I O N LVIII.

The colour that appears and disappears by the influence of the air.

PUT into a decanter volatile spirit in which you have dissolved copper filings, and you will have a fine blue tincture. If the bottle be stopped the colour will presently disappear, but when it is unstopped the colour will soon return: and this experiment may be repeated a greater number of times.

SYMPA-

SYMPATHETIC INKS.

BY sympathetic inks is meant, those sorts of liquors with which any characters being wrote they remain invisible, till some method is used to give them a colour. These liquors are divided into five classes, and that with respect to the means used to make them visible.

The first class of these inks are such as become visible by passing another liquor over them, or by exposing them to the vapour of that liquor.

The second are those that do not appear so long as they are kept close, but become soon visible on being exposed to the air.

The third are such as are made apparent by strewing or sifting some very fine powder, of any colour, over them.

The fourth are those that will not be visible till they have been exposed to the fire, or heated.

The fifth, like the fourth, appear by heat, but disappear again when the paper becomes cold, or has had a sufficient time to imbibe the moisture of the air.

The compositions of the first class of these inks.

Impregnation of Saturn.

Put litharge of lead into strong distilled vinegar, and let it stand for twenty-four hours. Then strain it off, and let it remain till quite settled. Preserve this liquor in a bottle.

Dissolve orpiment in water of quick lime*, either by a sand heat, or by setting

* Put in a pint bottle two ounces of quick lime, one ounce of orpiment in powder, and as much water as will rise two or three fingers above them. When the dissolution is made, pour the liquor gently off.

the

the bottle in the sun for two or three days, observing to turn it five or six times each day*.

In preparing these liquors you must take care that they have no communication; for the vapour of the latter is sufficient to destroy the limpidity of the other, and thereby render it unfit for use.

When the letters wrote by the first liquor are exposed to the vapour of the second, they become presently visible. If you would have them disappear again, you must draw a sponge or pencil, dipped in aqua fortis, or spirit of nitre, over them. If after this you would have them appear again, let the paper be quite dry by the air, and then pass the vivifying liquor, that is, the dissolution of orpiment, over them again.

* The vapour of this liquor should be kept from the mouth, as it is highly pernicious.

Another

Another ink of this class.

Dissolve bismuth in the nitrous acid. The letters wrote with this ink will become quite black by being exposed to the vapour of the liver of sulphur, which is of so penetrating a nature that it will act upon the ink through a quire of paper, or even the slight partition of a room.

Sympathetic gold ink.

Put as much gold into a small quantity of aqua regia as it will dissolve, and then dilute it with two or three times as much distilled water.

Dissolve, in a separate vessel, fine pewter in aqua regia, and when it is well saturated, add to it an equal quantity of distilled water.

Let the characters you write with the dissolution of gold become quite dry, in
the

the shade, and they will not appear for the first seven or eight hours. Dip a pencil, or small fine sponge, in the dissolution of pewter, and drawing it lightly over the invisible characters, they will presently appear of a purple colour.

The extraordinary effect of this sympathetic ink is an exception to the general chemical principles, for we here see two metallic substances, change their colour by mixture, without any apparent fermentation.

The purple colour of the letters may be effaced, by wetting them with aqua regia; and it may be produced a second time by passing the dissolution of pewter over them again. This dissolution of gold in aqua regia, as well as that of silver in the nitrous acid, being diluted by a sufficient quantity of water, will likewise serve to write letters that will disappear when they become dry, if they be carefully kept from

from the open air; but will be visible after being exposed an hour or two to the sun or the fire.

Another sympathetic ink.

Dissolve green vitriol in common water, and add a small quantity of nitrous acid, to prevent that yellowish precipitation that will otherwise be formed. The characters wrote in this dissolution with a new pen will be visible.

Infuse in water, or white wine, small Aleppo galls, lightly bruised*. At the end of two or three days pour the infusion cleanly off. By drawing a pencil dipped in this infusion over the letters wrote with the last dissolution, they will appear of a beautiful black, especially if the infusion be strong.

* You may put three-fourths of a pint of water or wine to two ounces of galls.

The letters wrote with the last dissolution will become a fine blue, if they be wetted with water saturated with Prussian blue: and letters wrote with this water, which will be invisible, will likewise turn to a fine blue, by being wetted with the above dissolution.

RECREATION LIX.

The book of fate.

MAKE a book of seventy or eighty leaves, and in the cover at the end of it let there be a case, which opens next the binding, that it may not be perceived.

At the top of each right hand page write any question you please, and at the beginning of the book let there be a table of all those questions, with the number of the page where each is contained. Then write with common ink, on separate papers, each about half the size of the pages
in

in the book, the same questions that are in the book, and under each of them write, with the ink made of the impregnation of Saturn, or the dissolution of bismuth, the answer.

Soak a double paper in the vivifying ink made of quick lime and orpiment, or the phlogiston of the liver of sulphur, and place it, just before you make the experiment, in the case that is in the cover of the book.

Then deliver some of the papers on which the questions are wrote to the company, and after they have chose such as they would have answered, they put them in those leaves where the same questions are contained, and shutting the book for a few minutes, the sulphureous spirit with which the paper in the cover of the book is imbibed, will penetrate the leaves, and make the answers visible, which will be of a brown colour, and more or less deep
in

in proportion to the time the book has been closed*.

RECREATION LX.

The marvellous portrait.

MAKE a box about four inches long, and three wide, as A B C D, (Plate XII. Fig. 5.) and quite shallow. Let it shut with hinges and fasten with a hook; and let it have two bottoms, the lowest of wood, that draws out by a groove, and the uppermost of pasteboard. Between these two bottoms is to be placed a paper dipped in the vivifying ink mentioned in the last Recreation. Let there be also a board of the same size with the inside of the box, which being placed in it may press a paper against the pasteboard bottom.

Then take several pieces of paper, of the same size with the inside of the box,

* If a weight be placed upon the book, the effect will be the sooner produced. Or you may put the book in a box that will press it close down.

and

and draw on them the figures of men and women, in different attitudes and employments, as walking, riding, reading, writing, &c. These figures must be drawn with a new pen or pencil, dipped in the impregnation of Saturn.

Being thus provided, and having privately placed the paper dipped in the vivifying ink between the two bottoms, you tell a person you will shew him what an absent friend of his is doing at the present hour. You then give him the paper adapted to the employment you intend, and tell him to write his friend's name at the bottom, that you may not change the paper. Then placing that paper next the paste-board bottom, and putting the piece of wood over it, you shut the box. After amusing him with discourse for three or four minutes, you take out the paper, when he will see his friend in the employment you have assigned him.

R E C R E

RECREATION LXI.

The artificial hand.

LET a workman make a hand of wood, (Plate XII. Fig. 6.) fixed at the end next the elbow to the piece E, the ends of which go through the screws C F and D G. The fore and middle fingers, and the thumb, are to be moveable at their joints. There must go a wire through the arm, that is fixed at one end to the fore finger, and at the other to the piece E, round which it is to move : under the two joints of the two fingers are also placed two small springs, which are to raise it up.

To the fore finger and thumb fix two small rings, through which a pen may be put, so as not to impede their motion. Under the arm, at the point I, place a small brass roller, which serves to sustain the arm.

The pedestal on which this hand is placed must be at least a foot long, if the hand be of the natural size, and about eight inches wide. This pedestal must be hollow, and at the part S T there must be an opening about three inches long and two inches wide ; the whole pedestal may be covered with a thin stuff, by which the hole will be concealed. There is to be a valve, or sort of trap-door, on the inside of the pedestal, which is to fasten against the opening.

Over the hand and pedestal place a glass frame, as in the figure : cover the hand with fine leather of flesh colour, and decorate the arm with a ruffle and cuff, which will entirely conceal the machinery.

Then take a number of cards and write on them different questions, and on the same number of papers write, with the impregnation of Saturn, the answers. Give the cards to any one, and let him choose a question, and you place the paper with
the

the answer under the pen in the hand, letting him first see there is no writing on it*. Now the pedestal being placed against a partition, the end F is to go thro' it. Therefore an assistant, upon a signal given, turns a handle fixed to F, and as piece E turns round the wires that moves the fingers and thumb are alternately lengthened and shortened, by which their joints are kept in continual motion; and the screw at the same time turning gently from F towards G, gives the whole arm a motion which very much resembles that of nature†.

* A paper dipped in the vivifying liquor is to be previously placed against the opening in the table, and supported by the tap-door.

† This might be performed without an assistant, by means of a trigger placed in the leg of the table, and communicating with the handles, which the operator might thrust down with his foot. Where expence is not regarded, there may be a complete figure of a man in wood, or plaister of Paris, seated by the table.

The hand and pen serve here merely to assist the illusion: but if a bit of sponge, dipped in the vivifying ink, be placed at the end of the pen, as it goes over the writing on the paper, it will make it become gradually visible, and in this case the trap door and dipped paper may be omitted*.

Sympathetic inks of the second class.

The sympathetic ink of gold, of which we have already given the composition, is also of this class; for without passing the dissolution of copper over it, when it is only exposed to the air an hour or two it becomes by degrees of a deep violet colour, that nearly approaches black.

* You may also have a glass ink-stand, with some of the vivifying liquor, into which the pen may be dipped, and it will then appear to write with common ink. The spectators should not be permitted to come very near this machine, which may be applied to several other purposes.

But

But if instead of exposing it to the air, you keep the paper on which it is wrote in a box shut close, or wrapt up in another paper, it will remain invifible for three or four months, but after that time it will become of a deep violet colour*.

Sympathetic filver ink.

Difolve fine filver in aqua fortis, and after the difolution add fome diftilled water, in the fame manner as in the gold ink. What is wrote with this ink, will remain invifible for three or four months, if it be kept quite close from the air, but will appear in an hour if exposed to the fun, and will be of a grey colour, like that of a flate.

Under this fecond clafs of fympathetics may be alfo included feveral other difolutions of metals, fuch as lead by vinegar,

* If in writing it make yellow fpoats on the paper, you muft add to it a little common water.

copper by aqua fortis, which gives the colour of tan on the paper; pewter by aqua regia; emery and certain pyrites, in spirit of salt; mercury in aqua fortis; or iron by vinegar. Each of these dissolutions exposed to the air have a particular colour; but they have the disagreeable quality of rotting the paper, so that after a certain time the characters appear like holes, in the same manner as if they had been cut out; they are therefore fit only for extempore recreations.

R E C R E A T I O N LXII.

The writing against the wall.

TAKE several pieces of paper, of a size that you can put in any book that will go into your pocket, and write at the top of each of them a question, with common ink, and under it write the answer with the gold or silver ink just mentioned. Give any one of these papers, closely wrapt up,

up, to a person, and tell him to place it against the wall of his chamber, and keeping the door locked he will next day find the answer wrote on it.

As the gold ink will sometimes give a yellow cast to the paper, you may previously give a slight tincture of that kind to the papers you use for this purpose.

R E C R E A T I O N LXIII.

The talisman.

MAKE a little triangular box, (Plate XII. Fig. 7.) each side of which is to be about five inches, and let its inside be divided into three parts. The first part A, which makes the bottom of the box, is to be covered by the second part B, in form of a case, and let the top C, exactly cover the part B; as is expressed in the figure and the profiles.

O 4

Upon

Upon the bottom of the box let there be a plate of copper, about one-twentieth of an inch thick, on which let there be a number of heiroglyphic characters, contiguous to each other, and cut in different sorts of metal.

On the top of the cover place a knob O, that goes through it, and to which the copper triangle Q is to be fixed occasionally, in such manner as it may go into the case B. There must be a space of one quarter of an inch between the triangle Q, and the bottom of the case B; into which another plate of copper, of that thickness, may be placed.

The outside of this talisman may be decorated with uncommon figures or characters, to give it the appearance of greater mystery.

On several pieces of paper, of the same size with the inside of the talisman, write
dif-

Fig. 1 p. 146.



Fig. 4 p. 149.



Fig. 6 p. 193



Fig. 5 p. 191



Fig. 2 p. 146.

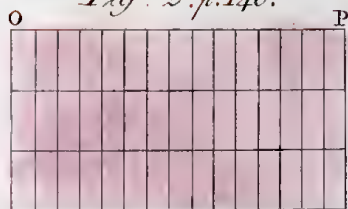


Fig. 7 p. 199.

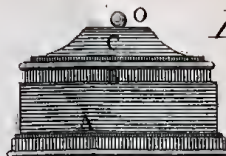
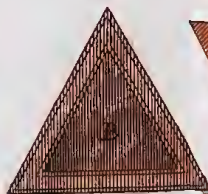


Fig. 3 p. 147.





different questions, in common ink, and write the answers in those different sorts of sympathetic ink, that appear when heated, observing that each word of the answer is to be wrote in a different ink*.

Having properly heated the triangle, and placed it under the cover, you introduce the talisman, and tell any one of the company to choose one of the papers on which the questions are wrote, and place it in the talisman, and he will immediately have an answer wrote on that paper, the words of which will be of different colours, according to the different metals of which the talisman is composed. The paper being placed in the talisman, and the cover placed over it, the heat of the triangle will make the answer visible in a few moments. This Recreation may be repeated if the triangle be made suffici-

* The inks proper for this purpose will be described further on.

ently hot; and two papers may be placed in the talifman at the same time.

This Recreation, when well executed, occasions a surprize that cannot be conceived by a mere description.

R E C R E A T I O N LXIV.

The sibyls.

MAKE a wooden pedestall A B, (Pl. XIII. Fig. 1.) about ten inches long, eight wide, and one deep: and at one end erect a box C, about ten inches high, eight broad, and two and a half deep.

The top of the pedestall must slide in a groove, on which inscribe a dial M, of six inches diameter, which is to be divided into nineteen parts; in twelve of which write the names of the months, and mark the respective signs of the zodaic and in the seven other divisions, which
must

must be next the end B, write the days of the week, and mark the figures of the planets. Next the inner circle NO, make an opening into the box of about one-tenth of an inch. On the center of the dial, place an index M, that turns freely on its center.

Within the pedestal place a pulley P, about four inches diameter, which is to turn on an axis that is directly under the center of the dial, and on the upper part of that axis fix a bent index R, which comes out at the opening made by the inner circle*, and passes over those seven divisions only, on which are wrote the days of the week.

Within the box C, let there be two rollers S, and T, as in the figure: let that of S contain a spring, and at the end of T let there be a pulley V of three quarters of an inch diameter, round which goes a string

*If the axis be made to pass through the top of the pedestal, this opening will not be necessary.

or

or thread that passes under the small pulley X, and is fastened to that of P: so that when the last pulley makes about one-third of a turn, that of V may make three or four turns.

There must be also a scroll of paper, about two feet long, and each end of which must be pasted to one of the rollers. In the front of the box between the two rollers, make an aperture D, about four inches long, and one inch and a half wide: to this opening let there be a little flap or slider, by which it may be closed at pleasure.

The apparatus being thus disposed, place the index R successively against each of the divisions marked with one of the planets, and as the paper is gradually wound up the roller, mark against that part which is at the aperture D, the name of one of the following sibyls.

The

The Hellispontian	}	fibyl.
Cumean		
Artemifian		
Phrygian		
Albunean		
Perfian		
Lybian		

On each of the seven cards write a different question, and draw one of the seven planets. Next, take a memorandum-book, that contains seven leaves, and on each of them write the name of one of the foregoing fibyls; in each of the leaves place several pieces of paper, and on each of them write, with the sympathetic ink that does not appear till the paper is heated, different answers to the same questions.

Then give a person the seven cards on which the questions are wrote, and tell him to choose one of them privately, and conceal the rest, so that it cannot possibly be known which of them he has chose.

Next

Next tell him to place the index that points to the month against that in which he was born*, and to place the index of the plant against that which is on the card he has chose, and which is to preside over the answer: you tell him to do this privately, that no one may see him, and after that to cover the dial with his handkerchief. Then let him open the door that is before the aperture in the box, and tell you the name of the sibyl there visible.

You then open the memorandum-book, and taking out the papers that are in the leaf where the name of the sibyl just mentioned is wrote, you desire him to choose any one of them he thinks proper. The talisman used in the last Recreation being properly heated, is then to be introduced, when you direct the person to put the

* These months and the index are of no other use than to give the experiment an air of greater mystery.

blank paper into it, and taking it out a few moments after, he will find the answer to his question.

To make this operation appear the more extraordinary, it will be proper to have a small press or cupboard, at the back of which there is a door that opens into an adjoining room, by which means an assistant having prepared the talisman may place it in the cupboard the moment before it is wanted. This contrivance will be useful on many other occasions.

RECREATION LXV.

The magic urn.

PROVIDE an urn of wood or metal about six inches high and two and a half diameter in the widest part, and of such figure in other respects as you think proper (see Pl. XIII. Fig. 2) Let there be a cylinder of copper C, Fig. 3. of about one-eighth of an inch diameter, which is
to

to fill a hole A B, made in the urn. The top of this cylinder is to be in the top of the urn, so that it may be easily taken out. To this urn there must be a cover D, which fits it exactly.

On a small square piece of paper draw the figure of a flower or leaf, with that sort of sympathetic ink, whose colour most resembles it. You then present several sorts of flowers or leaves to a person, and desire him to choose any one of them. Then put that flower on a chaffingdish of hot coals, and taking the paper on which it is secretly drawn, you give it to the person to examine, and then put it in the urn, having previously heated the cylinder*. Then taking some of the ashes of the burnt flower, you strew them over the paper, after which you take it out and shew the company the figure of that flower. While the flower is burning you

* There are some sorts of sympathetic inks that require much more heat than others.

may sprinkle some powder over it, suppose that of saltpetre, and by that, mixed with the ashes of the flower, the company may imagine the effect is produced.

The press or cupboard mentioned in the last Recreation will be here very convenient for heating the cylinder and placing it in the urn. A similar Recreation may be performed by putting the paper in a copper vessel, that may be placed on an iron plate over the chafingdish in which the flower is burnt. But this method has not so mysterious an appearance as the other, and in some persons may cause a suspicion that the effect is produced by heat.

Other sympathetic inks.

Beside those mentioned in the beginning of this article there are several other inks which appear very lively when a

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coloured liquor is passed lightly over them, of which the following are the most material.

A yellow fympathetic ink is made by steeping the flowers of the marygolts seven or eight days, or more, in clear distilled vinegar, and then pressing them out. The liquor is to be kept in a bottle well corked. If you would have it still more limpid, add at the time of using it some clear water.

For a red invisibile ink ; to the pure spirit of vitriol or that of nitre, add eight or ten times as much water, as you would have it more or less red.

For a green ink of this sort, dissolve salt of tartar, the clearest, and driest you can procure, in a sufficient quantity of river water.

For

For a violet sympathetic ink, exprefs the juice of lemons and keep it in a bottle well corked.

All that is wrote on paper, or any white body, fuch as filk, cloth, &c. with one of thofe inks, will appear of the colour above expreffed, after it has been dipped in the following liquor. Take a fufficient quantity of the flowers of pancy, or of the common violet, and bruife them in a mortar, adding fome water to them, and ftraining the liquor through a cloth, keep it in a bottle; or take water in which turnfole has been fteeped.

R E C R E A T I O N LXVI.

The revived bouquets.

PROVIDE a number of artificial flowers, such as roses, jonquils, pinks, or any other you find convenient. These flowers must be made of white thread or silk, and their leaves of parchment. Dip the roses in the red sympathetic ink, the jonquils in the yellow, the pinks in the violet, and their leaves in the green ink. When they are all dry form them into small bouquets, which will all appear white and may be used in this Recreation, either the day they are dipped, or several days after.

You take one of these bouquets, and after showing the company that every part of it is white, you dip it in the vivifying liquor made of violets, just described,
and

and drawing it presently out, all the flowers and leaves will appear in the natural colours*.

R E C R E A T I O N LXVII.

The transcoloured writing.

WRITE on a paper, with the violet liquor, as many letters or words as you please; and ask any person whether he will have that writing turn to yellow, green, or red.

Have a sponge with three sides that you can readily distinguish, and dip each of its sides in one of the three sympathetic inks. Draw the side of the sponge that corresponds to the colour the person has

* The vivifying liquor should be put in a sort of jar, with a narrow neck, that it may not be seen by the company; and you should draw the flowers gently out, that the liquor may drop, if thin, and they may have time to acquire their colours.

chofe, over the writing once only ; and it will directly change to the colour required*.

Sympathetic inks of the third clafs.

Thefe, as we have faid, are fuch as become vifible by having any fine powder ftrewed over them, and may be compofed of the glutinous and colourlefs juice of any vegetable, the milk of animals, and many other fubftances.

R E C R E A T I O N LXVIII.

Magical vegetations.

ON different papers draw the figures of feveral leaves or flowers with one of the colourlefs juices above mentioned : then take one of the correfponding leaves or flowers, and laying it on an iron plate over a chaffingdifh of hot coals, let it burn

* The fponge fhould be well cleaned immediately after the experiment.

to ashes. Put these ashes into a sieve, in which there is some very fine steel filings, and sift them over the paper on which the flower is drawn, when they will adhere to the glutinous liquor, and form an exact representation of the figure of the leaf or flower.

Sympathetic inks of the fourth class.

This class, comprehending all those that become visible by being exposed to the fire; is very extensive, as it contains all those infusions and dissolutions, in which the matter dissolved is capable of being reduced into a sort of charcoal by a small heat. A few examples of these inks will here suffice, and the rather, as most of those of the first class which appear on being exposed to the air, are of this class likewise.

These inks may be made by a strong dissolution of vitriol in common water, or

P 4 of

of the juice of lemons or onions; the two latter requiring less heating than the first, but they will not keep so long.

R E C R E A T I O N LXIX.

The transmutable cards.

IN a common pack of cards, let the ace of hearts and nine of spades be some thing larger than the rest. With the juice of lemon drawn over the ace of hearts a spade, large enough to cover it entirely, and on each side draw four other spades.

Present the pack to two persons, so adroitly, that one of them shall draw the ace of hearts and the other the nine of spades, and tell him who draws the latter, to burn it on a chafingdish. You then take the ashes of that card, and put them into a small metal box, and give it to him who has the ace of hearts, that he may himself put that card into the box and fasten it. Then put the box for a short time

time on the chafingdish, and let the person who put the card in it, take it off and take out the card, which he will see is turned to the nine of spades*.

RECREATION LXX.

The convertible cards.

TO perform this Recreation you must observe that there are several letters which may be changed into others, without any appearance of the alteration; as the *a* into *d*, the *c* into *a*, *e*, *d*, *g*, *o*, or *q*, the *i* into *b*, *d*, or *l*, the *l* into *t*, the *o* into *a*, *d*, *g*, or *q*, the *v* into *y*, &c.

Take a parcel of cards, suppose 20, and on one of them write, with the ink of the fourth class the word *law*†, and on

* In making this experiment the chafingdish should not be brought into the room till the two cards are drawn, that if the parties should not draw those cards you may exhibit some other recreation.

† These letters should not be joined.

the

the other, with the same ink, the words *old woman*; then holding them to the fire they will both become visible. Now you will observe that by altering the *a* in the word *law* into *d*, and adding *o* before the *l*, and *oman* after the *w*, it becomes *old woman*. Therefore you make those alterations with the invisible ink, and let it remain so. On the rest of the cards you write any words you think fit.

Present the cards in such manner to two persons, that one of them shall draw the word *law*, and the other the words *old woman*. You then tell the person who drew the word *law*, that it shall disappear, and the words on the other card shall be wrote in its place: and that you may not change the cards, desire each of the parties to write his name on his card. Then putting the cards together, and holding them before the fire, as if to draw the names just wrote, the word *law* will presently change into *old woman*.

This

This Recreation may be varied by fixing on a word that may be changed into three other words, and making four persons draw the cards on which those words are wrote ; and it may be further diversified by choosing three such words, as that the first can be changed into the second, and the second into the third. You then tell him who drew the first word, that it shall be changed into that drawn by the second person ; and him you tell, that his word shall be changed into that of the third person.

RECREATION LXXI.

The oracular letters.

WRITE on several slips of paper different questions, and such as may be answered by the name of some person ; for example, Who is the merriest man in the company ? Answer, Mr. ****. To whom will Miss *** be married ? Answer,

swer, To Mr. ***. These questions are to be wrote in the fympathetic ink of this clafs, and expofed to the fire, and the answers wrote in the fame ink, and left invifible. The papers are to be folded in form of letters, and in fuch manner that the part where the name is wrote fhall be directly under the feal, and the heat of the wax will make it vifible. Then give the letter to the perfon who requires the answer, and he will find it plainly wrote.

A recreation fimilar to this may be made with a number of blank cards, on each of which an ace of fpades is drawn with the invifible ink; then let a perfon choofe any one of them, and enclofe it in a letter cafe, prepared in fuch manner that the figure of the ace fhall be directly under the feal, and on opening the letter it will be immediately vifible.

Sympa-

*Sympathetic inks of the fifth class.**The green ink.*

Take zaffre in powder, and let it remain for dissolution in aqua regia during twenty-four hours. Pour the liquor off clear, and add to it as much or more common water, and keep it in a bottle well corked.

This ink will not be visible till it has been exposed to the fire, or to the strong rays of the sun. The characters will then be of a lively green. It is the peculiar property of this ink, that as soon as the paper becomes cold again the letters disappear, and this alternate appearance and disappearance may be repeated a great number of times, provided that by too great heat the letters never acquire the colour

lour of fillemot, for after that they will never disappear*.

RECREATION LXXII.

The incomprehensible writing.

HAVE a box that is divided into three parts, after the same manner as the talisman in the 63d Recreation, except that instead of being triangular. it must be of a long square, (see Plate XIII. Fig. 4.) Divide its top B into two equal parts D and E, as in Fig. 5. and to the part D adjust a plate of copper L, about one quarter of an inch thick, and under both the plate L and the opening E, place a cloth. The upper part C must have a button by which it may be fixed on the

* This ink may be also made of cobalt, in the manner described by M. Hellot, in the memoires de l'Academie des Sciences for 1737; but that method is far more embarrassing to such as are not used to chemical operations.

cover

cover B, so as to appear of one piece with it.

At the bottom of the box place a piece of cloath, or other stuff, on which you may stamp certain mysterious characters, and observe that the bottom of the cover must rest upon this cloth.

Then provide a slip of paper G H, Fig. 6. of the same size with the bottom of the box, and at each end of it write, with the green sympathetic ink, the name of a different card, and make some private mark, by which you can tell at which end each name is wrote*.

Take a parcel of cards, and offer those two of them whose names are wrote on the paper to the two persons, that they

* That there may be no suspicion of the papers being prepared, you may cut it from a whole sheet, before the company, having previously wrote the names.

may

may draw them. You tell the parties to keep their cards to themselves, and you propose to make the names of those cards appear upon a slip of paper, which you put into the box. You then ask which name of the two cards shall appear first. The copper plate being previously heated and placed in the cover, you put it over that end of the paper on which is the name required, and it will presently appear. Then taking the paper out and showing the name wrote, you put it in again, turning the other end to the side of the box where the plate is, and it will in like manner become visible.

The first name may be made to disappear at the same time that the second appears, if the cloth at the end opposite to that where the plate is, be made damp.

R E C R E -

RECREATION LXXIII.

Winter changed to spring.

TAKE a print that represents winter, and trace over the proper parts of the trees, plants, and ground with the green sympathetic ink ; observing to make some parts deeper than others, according to their distance. When those parts are dry, paint the other objects with their natural colours. Then put the print in a frame with a glass, and cover the back of it with a paper that is pasted over its border only.

When this print is exposed to the heat of a moderate fire, or to the warm rays of the sun, all the grass and foliage will turn to a a pleasing green, and if a yellow tint be given to some parts of the print, before the sympathetic ink be drawn over it, this green will be of different shades ; and the scene that a minute before repre-

fented winter, will now be changed to spring. When this print is placed in the cold, winter will again appear, and will again be driven away by the warm rays of the sun. This alternate change of seasons may be repeated as often as you please ; remembering, however, as was before observed, not to make the print at any time too hot, for then a faded autumn will for ever remain.

*Sympathetic ink that appears by being
wetted with water.*

Mix alum with a sufficient quantity of lemon juice. The letters wrote with this mixture will be invisible till they are wetted with water, and then will appear of a greyish colour and transparent.

Or you may write with a strong dissolution of rock alum only, and when the writing is dry, pour a small quantity of water over it, and it will appear of a
white,

white, like that of the paper before it was wetted.

All saline liquors, such as vitriolic, nitreous, and marine acids, diluted with water; the liquor of fixed vegetable alkalis, and even vinegar, will produce the same effect.

When the paper is strong and contains a sufficient quantity of size, and the saline liquors are properly diluted, as, for example, when one ounce of aqua fortis is mixed with three or four ounces of water, the writing will dry well, become absolutely invisible, and not run out of its form when the paper is wetted. As the paper dries it will become again invisible, and may be made to appear and disappear many times.

This sort of ink is very convenient, as it may be easily prepared with many substances that are readily procured, and

as it does not require heating, nor the assistance of any other liquor, except common water*.

RECREATION LXXIV.

The oracular mirror.

PROVIDE a round mirror, (Plate XIII. Fig. 7.) of about three inches diameter, and whose frame is an inch wide. Line the under part of the frame, in which holes are to be cut, with very thin glass; behind this glass let the mirror ABCD, of about two inches diameter, be placed, which is to be moveable, so that by inclining the frame to either side, part of the mirror will be visible, behind the glass, on that side.

* They who would amuse themselves further with these matters, may consult a treatise wrote expressly on the subject, by that bright luminary in the British hemisphere of science, the sagacious Boyle.

Then

Fig. 1. p. 202.

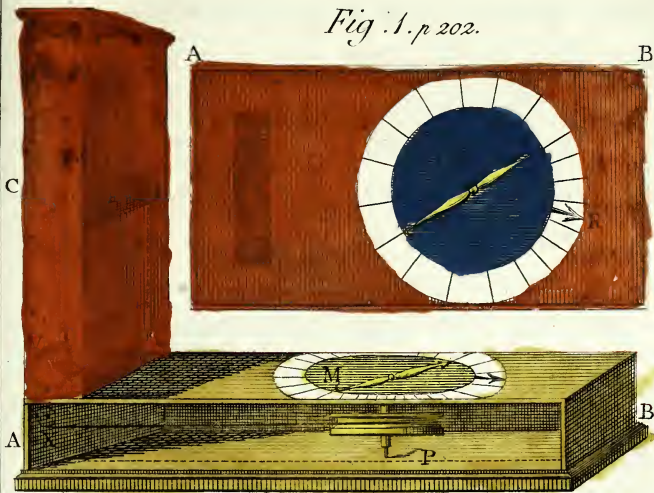


Fig. 2. p. 207.

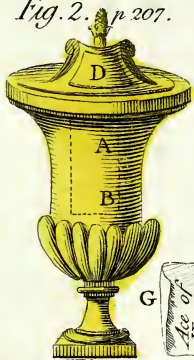


Fig. 3. p. 207.



Fig. 7. p. 228.

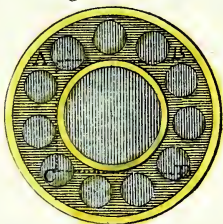


Fig. 6. p. 223.



Fig. 4. p. 222.

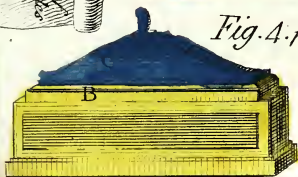


Fig. 5. p. 222.





Then take Spanish chalk, or Cyprus vitriol, of which you make a pencil, and with this you may write on a glass and rub it off with a cloth, and by breathing on the glass the writing will appear and disappear several times. With this pencil write on one side of the mirror, before it is put in the frame, the word *yes*, and on the other side, *no*; and wipe them off with a cloth.

You propose to a person to ask any question of this mirror that can be answered by the words *yes* or *no*. Then turning the glass to one side, and putting your mouth close to it, as if to repeat the question softly, you breathe on it, and the word *yes* or *no* will immediately appear. This mirror will serve for many other agreeable amusements.

R E C R E A T I O N LXXV.

The tree of Diana.

TAKE half an ounce of fine silver, either in filings or cut small, and two drams of mercury, and dissolve them in three or four ounces of aqua fortis. When the dissolution is perfectly made, pour it into a pint of common water, and stir it about, that the whole may be well mixed. Keep this preparation in a bottle well corked.

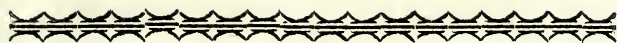
In a small phial put the quantity of a pea, of the amalgam of silver with mercury, and pour an ounce of the above liquor over it. There will presently rise from that little globular amalgam small branches, that by encreasing will form a kind of shrub, or bushy tree, of a silver colour.

Another

Another way of producing this appearance is by dissolving an ounce of fine silver in three ounces of strong aqua fortis, in a glass or earthen vessel. When the silver is quite dissolved, pour the aqua fortis into another glass vessel, wide at the bottom, with seven or eight ounces of mercury, and add one quart of common water: to the whole add your dissolved silver, and let it remain untouched.

In a few days the mercury will appear to be covered with a multitude of little branches, resembling slender shrubs, and of a silver colour. This appearance will continually increase for a month or two, and will remain after the mercury is entirely dissolved*.

* It was very likely some experiment like this, together with a deception similar to that used in a foregoing Recreation, that gave rise to the pretended experiment of producing a tree or flower from its ashes, which many have thought possible, and for the performing of which Paracelsus and Kircher have each of them given a regular process, which serves only to show what low arts and effrontery, have been practised by men of letters in ignorant ages.



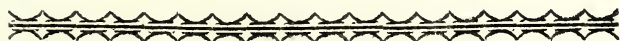
R E C R E A T I O N S

O F

A D D R E S S S

A N D

D E X T E R I T Y.



RECREATIONS WITH THE CARDS*.

Previous to these recreations with the cards, it will be necessary to explain the method of *making the pass* : that is, bringing a certain number of cards from the bottom of the pack to the top ; as many of these recreations depend on that manœuvre.

HOLD the pack of cards in your right hand, so that the palm of your hand may be under the cards : place the thumb of that hand on one side of the pack, the first, second, and third fingers on the other side, and your little finger between those cards that are to be brought to the top, and the rest of the pack. Then place your left hand over the cards. in such manner, that the thumb may be at C, (Pl. XIV. Fig 1, and 2.) the forefinger at A, and the other fingers at B.

* Several of these recreations were invented by M. Guyot.

The

The hands and the two parts of the cards being thus disposed, you draw off the lower cards confined by the little finger and the other parts of the right hand, and place them, with an imperceptible motion, on the top of the pack.

It is quite necessary, before you attempt any of the recreations that depend on making the pass, that you can perform it so dextrously that the eye cannot distinguish the motion of your hand ; otherwise, instead of deceiving others you will expose yourself. It is also proper that the cards make no noise, as that will occasion suspicion. This dexterity is not to be attained without some practice.

We have mentioned in the first volume the method of preparing a pack of cards, by inserting one or more that are a small matter longer or wider than the rest, and that preparation will be necessary in several of the following recreations.

R E C R E -

RECREATION LXXVI.

The card of divination.

HAVE a pack in which there is a long card; open the pack at that part where the long card is, and present the pack to a person in such manner that he will naturally draw that card*. He is then to put it into any part of the pack, and shuffle the cards. You take the pack and offer the same card in like manner to a second or third person; observing, however, that they do not stand near enough to see the card each other draws. You then draw several cards yourself, among which is the long card, and ask each of the parties if his card be among those cards, and he will naturally say yes, as they have all drawn the same card. You then shuffle all the cards together, and cutting them at the long card, you hold

* See Vol. I. p. 78.

it before the first person, so that the others may not see it, and tell him that is his card. You then put it again in the pack, and shuffling them a second time, you cut again at the same card, and hold it in like manner to the second person, and so of the rest*.

If the first person should not draw the long card, each of the parties must draw different cards; when cutting the pack at the long card, you put those they have drawn over it, and seeming to shuffle the cards indiscriminately, you cut them again at the long card, and show one of them his card. You then shuffle and cut

* There is frequently exhibited another experiment, similar to this, which is by making a person draw the long card, then giving him the pack, you tell him to place his card where he pleases, and shuffle them, and you will then name his card, or cut the pack where it is. You may also tell him to put the pack in his pocket, and you will draw the card, which you may easily do by the touch.

again

again in the same manner, and show another person his card, and so on : remembering that the card drawn off by the last person is the first next the long card ; and so of the others.

This recreation may be performed without the long card, in the following manner. Let a person draw any card whatever, and replace it in the pack : you then make the pass, and bring that card to the top of the pack, and shuffle them without losing sight of that card. You then offer that card to a second person, that he may draw it, and put it in the middle of the pack. You make the pass and shuffle the cards a second time, in the same manner, and offer the card to a third person, and so again to a fourth or fifth, as is more fully explained further on.

R E C R E A T I O N LXXVII.

The four confederate cards.

YOU let a person draw any four cards from the pack, and tell him to think on one of them. When he returns you the four cards you dextrously place two of them under the pack and two on the top. Under those at the bottom you place four cards of any sort, and then taking eight or ten from the bottom cards, you spread them on the table, and ask the person if the card he fixed on be among them. If he say *no*, you are sure it is one of the two cards on the top. You then pass those two cards to the bottom, and drawing off the lowest of them, you ask if that is not his card. If he again say *no*, you take that card up, and bid him draw his card from the bottom of the pack.

If the person say his card is among those you first drew from the bottom, you
must

must dextrously take up the four cards that you put under them, and placing those on the top, let the other two be the bottom cards of the pack, which you are to draw in the manner before described.

R E C R E A T I O N LXXVIII.

The numerical card.

LET the long card be the sixteenth in a pack of piquet cards. Take ten or twelve cards from the top of the pack, and spreading them on the table desire a person to think of any one of them, and to observe the number it is from the first card. Make the pass at the long card, which will then be at the bottom. Then ask the party the number his card was at, and counting to yourself from that number to 16, turning the cards up one by one, from the bottom. Then stop, at the seventeenth card, and ask the person if he has seen his card, when he will say *no*. You then ask him how many more cards

you shall draw before his card appears ; and when he has named the number, you draw the card aside with your finger, and turn up the number of cards he proposed, and then throw down the card he fixed on.

R E C R E A T I O N LXXIX.

Divination by the sword.

AFTER a card has been drawn you place it under the long card, and by shuffling them dextrously you bring it to the top of the pack. Then lay, or throw, the pack on the ground, observing where the top card lays. A handkerchief is then bound over your eyes, in such manner however that you can see the ground, which may be easily done. A sword is then put into your hand, with which you touch several of the cards, seemingly in great doubt, but never losing sight of the top card, in which at last you fix the point
of

of the sword, and present it to him who drew it. Two or three cards may be discovered in the same manner, that is, by placing them under the long card, and then bringing them to the top of the pack.

RECREATION LXXX.

The card thought on per force.

YOU spread part of a pack of cards before a person, in such manner that one of the picture cards only is completely visible. You then tell him to think on one of those cards, observing attentively if he fix his eye on the picture card. When he says he has determined, you shuffle the cards, and turning them up, one by one, you tell him that is his card.

If he does not appear to fix his eye on the pictured card, or if he spread the cards in order to fix on another, you tell him to draw the card he chooses, and then by

placing it under the long card you perform some other recreation. It is easy to conceive that this recreation may fail, and that it should not be attempted with those who are conversant with deceptions of this sort.

R E C R E A T I O N LXXXI.

The transmutable cards.

YOU must have in the pack two cards of the same sort, suppose the king of spades. One of these is to be placed next the bottom card, which may be the seven of hearts, or any other card. The other is to be placed at top. You then shuffle the cards, without displacing those three cards, and show a person that the bottom card is the seven of hearts. Then drawing that card privately aside with your finger, which you have wetted for that purpose, you take the king of spades from the bottom, which the person supposes to be the seven of hearts, and lay it on the table,

table, telling him to cover it with his hand. You then shuffle the cards again, without displacing the first and last card, and passing the other king of spades at the top to the bottom, you show it to another person. You then draw that privately away, and taking the bottom card, which will then be the seven of hearts, you lay that on the table, and tell the second person, who believes it to be the king of spades, to cover it with his hand.

You then command the seven of hearts, which is supposed to be under the hand of the first person, to change into the king of spades; and the king of spades, which is supposed to be under the hand of the second person, to change into the seven of hearts; and when the two parties take their hands off, and turn up the cards, they will see, to their no small astonishment, after having so carefully observed the bottom cards, that your commands are punctually obeyed.

RECRE-

R E C R E A T I O N LXXXII.

The three magical parties.

YOU are to offer the long card to any one, that he may draw it, and place it again in any part of the pack he thinks proper. You then make the pafs, and bring that card to the top of the pack. You next divide the pack into three heaps, obferving to put the long card in the middle heap, as that is moft commonly chofe. You then demand of the perfon which of the heaps the card he drew fhall be in. If he reply in the middle parcel, you immediately fhew him the card. But if he fay in either of the others, you take all the cards in your hand, placing the parcel he has named over the other two, obferving to put your little finger between that and the middle heap, at the top of which is the card he drew. You then ask at what number in that heap he will have his card appear.

appear. If he say, for example, the sixth card, you tell down five cards from the top of the pack, and then dextrously making the pass, you bring the long card to the top, and tell it down as the sixth.

R E C R E A T I O N LXXXIII.

The inverted cards.

PREPARE a pack of cards, by cutting one end of them about one-tenth of an inch narrower than the other: then offer the pack to any one that he may draw a card; place the pack on the table, and observe carefully if he turn the card while he is looking at it: if he do not, when you take the pack from the table, you offer the other end of it for him to insert that card; but if he turn the card, you then offer him the same end of the pack. You afterwards offer the cards to a second or third person, for them to

R 4

draw

draw and replace a card in the same manner. You then let any one shuffle the card and taking them again in your own hand, as you turn them up one by one, you easily perceive by the touch which those cards are that have been inverted, and laying the first of them down on the table, you ask the person if that card be his, if he say *no*, you ask the same of the second person, and if he say *no*, you tell the third person it is his card ; and so of the second and third cards. You should lay the pack on the table after each person has drawn his card, and turn it dextrously in taking it up, when it is to be turned, that the experiment may not appear to depend on the cards being inverted.

RECRE-

RECREATION LXXXIV.

The card discovered by the touch or smell.

YOU offer the long card, or any other that you know, and as the person who has drawn it holds it in his hand, you pretend to feel the pips or figure on the under side by your fore finger ; or you fagacioufly smell to it, and then pronounce what card it is.

If it be the long card, you may give the pack to the person who drew it, and leave him at liberty either to replace it, or not. Then taking the pack, you feel immediately whether it be there or not, and shuffling the cards in a careless manner, without looking at them, you pronounce accordingly.

R E C R E -

RECREATION LXXXV.

The incomprehensible transposition.

TAKE a card, the same as your long card, and rolling it up very close, put it in an egg, by making a hole as small as possible, and which you are to fill up carefully with white wax. You then offer the long card to be drawn, and when it is replaced in the pack you shuffle the cards several times, giving the egg to the person who drew the card, and while he is breaking it, you privately withdraw the long card, that it may appear, upon examining the cards, to have gone from the pack into the egg. This Recreation may be rendered more surprising by having several eggs, in each of which is placed a card of the same sort, and then giving the person the liberty to choose which egg he thinks fit.

This

This deception may be still further diversified, by having, as most public performers have, a confederate, who is previously to know the egg in which the card is placed; for you may then break the other eggs, and show that the only one that contains a card is that in which you directed it to be.

RECREATION LXXXVI.

The card in the pocket-book.

THIS Recreation is to be performed by a confederate, who is previously to know the card you have taken from the pack and put in your pocket-book. You then present the pack to your confederate, and desire him to fix on a card, (which we will suppose to be the queen of diamonds) and then place the pack on the table. You then ask him the name of the card, and when he says the queen of diamonds, you ask him if he be not mistaken, and if he be

be sure that card is in the pack: when he replies in the affirmative, you say, it might be there when you looked over the cards, but I believe it is now in my pocket: then desire a third person to put his hand in your pocket, and take out your book, and when it is opened the card will appear.

Experiments of this kind appear as wonderful to those who have no idea of a confederacy, as they do simple and trifling to those that are in the secret.

R E C R E A T I O N LXXXVII.

To tell the card that a person has only once touched with his finger.

THIS Recreation also is to be performed by confederacy. You previously agree with your confederate on certain signs, by which he is to denote the suit, and the particular card of each suit; as
thus:

thus: if he touch the first button of his coat, it signifies an ace; if the second, a king, &c. and then again if he take out his handkerchief, it denotes the suit to be hearts; if he take snuff, diamonds, &c. These preliminaries being settled, you give the pack to a person who is near your confederate, and tell him to separate any one card from the rest, while you are absent, and draw his finger once over it. He is then to return you the pack, and while you are shuffling the cards, you carefully note the signals made by your confederate. Then turning the cards over one by one, you directly fix on the card he touched.

R E C R E A T I O N LXXXVIII.

To name several cards that two persons have drawn from the pack.

DIVIDE a piquet pack of cards into two parts by a long card. Let the first part contain a quint to a king in clubs and spades, the four eights, the ten of diamonds, and ten of hearts; and let the other part contain the two quart majors in hearts and diamonds, the four sevens and the four nines*.

Then shuffle the cards, but observe not to displace any of those cards of the last part which are under the long card. You then cut at that card, and leave the pack in two parts. Next, present the first of those parts to a person, and tell him to draw two or three cards, and place the

* The cards may be divided in any other manner that is easy to be remembered.

remainder

remainder on the table. You present the second parcel in like manner to another. Then having dextrously placed the cards drawn by the first person in the second parcel, and those drawn by the second person in the first parcel, you shuffle the cards, observing to displace none but the upper cards. Then spreading the cards on the table, you name those that each person drew; which you will very easily do, by observing the cards that are changed in each parcel.

RECREATION LXXXIX.

The two convertible aces.

ON the ace of spades fix with soap, a heart, and on the ace of hearts a spade, in such manner that they will easily slip off.

Show these two aces to the company; then taking the ace of spades you desire a person

person to put his foot upon it, and as you place it on the ground, draw away the spade. In like manner you place the seeming ace of hearts under the foot of another person. You then command the two cards to change their places; and that they obey your command, the two persons, on taking up their cards, will have ocular demonstration.*

* A deception similar to this is sometimes practised with one card, suppose the ace of spades, over which a heart is pasted slightly. After showing a person the card you let him hold one end of it, and you hold the other, and while you amuse him with discourse you slide off the heart. Then laying the card on the table you bid him cover it with his hand. You then knock under the table, and command the heart to turn into the ace of spades. By deceptions like these people of little experience and much conceit are frequently deprived of their money and rendered ridiculous.

R É C R E -

RECREATION XC.

The fifteenth thousand livres.

YOU must be prepared with two cards, like those represented by Plate XIV. Fig. 3. and with a common ace and five of diamonds.

The five of diamonds and the two prepared cards are to be disposed as in Fig. 4. and holding them in your hand, you say, "A certain Frenchman left fifteen thousand livres, which are represented by these three cards to his three sons. The two youngest agreed to leave their 5000, each of them, in the hands of the elder, that he might improve it." While you are telling this story you lay the 5 on the table, and put the ace in its place, and at the same time artfully change the position of the other two cards, that the three cards may appear, as in Fig 5. You then resume your discourse.. "The eldest brother, instead

of improving the money, lost it all by gaming, except three thousand livres, as you here see." You then lay the ace on the table, and taking up the 5, continue your story: "The eldest, sorry for having lost the money, went to the East-Indies with these 3000, and brought back 15000." You then shew the cards in the same position as at first, in Fig. 3.

To render this deception agreeable, it must be performed with dexterity, and should not be repeated, but the cards immediately put in the pocket; and you should have five common cards in your pocket, ready to shew, if any one should desire to see them.

Another recreation of this sort may be performed with fives and threes, as in Fig. 6, 7, and 8.

RECRE-

RECREATION XCI.

The card discovered under the handkerchief.

LET a person draw any card from the rest, and put it in the middle of the pack. You make the pafs at that place, and the card will consequently be at top. Then placing the pack on the table, cover it with a handkerchief, and putting your hand under it, take off the top card, and after seeming to search among the cards for some time, draw it out.

This recreation may be performed by putting the cards in another person's pocket, after the pafs is made. Several cards may also be drawn and placed together in the middle of the pack, and the pafs then made.

R E C R E A T I O N XCII.

To change the cards that several persons have drawn from the pack.

ON the top of the pack put any card you please, suppose the queen of clubs. Make the pass, and bring that card to the middle of the pack, and offer it a person to draw. Then, by cutting the cards, bring the queen again to the middle of the pack. Make the pass a second time, and bring it to the top, and shuffle the cards without displacing those on the top. Make the pass a third time, and bring it to the middle of the pack, and offer it to a second person to draw; who must be at a proper distance from the first person, that he may not perceive it is the same card. After the like manner did five persons draw the same card.

Shuffle the pack, without losing sight of the queen of clubs, and laying down
four

four other cards with the queen, ask each person if he sees his card there. They will all reply *yes*, as they all drew the queen of clubs. Place four of those cards to the pack, and drawing the queen privately away; you approach the first person, and showing him that card, so that the others cannot see it, and ask if that be his card. Then putting it on the top of the pack blow on it, or give it a stroke with your hand, and shew it in the same manner to the second person; and so of the rest.

R E C R E A T I O N XCIII.

The four inseparable kings.

TAKE the four kings, and behind the last of them place two other cards, so that they may not be seen. Then spread open the four kings to the company, and put the six cards at the bottom of the pack. Draw one of the kings, and put him at the top of the pack. Draw

one of the two cards at the bottom and put it towards the middle. Draw the other, and put it at some distance from the last, and then show that there remains a king at bottom. Then let any one cut the cards, and as there remained three kings at bottom, they will then be altogether in the middle of the pack.

RECREATION XCIV.

To tell the number of cards by their weight.

TAKE a parcel of cards, suppose 40, among which insert two long cards; let the first be, for example, the 15th, and the other the 26th from the top. Seem to shuffle the cards, and then cutting them at the first long card, poise those you have cut off in your left hand, and say, "there should be here fifteen cards." Cut them again at the second long card, and say, "there are here only eleven cards." Then poising the remainder, you say, "here are fourteen cards."

RE-

RECREATION XCV.

To discover the card that is drawn by the throw of a die.

PREPARE a pack of cards, in which fix different cards are contained fix times; that is in which there are only fix sorts of cards. Dispose these cards in such manner that each of the fix different cards shall follow each other, and let the last of each suit be a long card. The cards being thus disposed, it follows, that if you divide them into fix parcels, by cutting at each of the long cards, those parcels will all consist of similar cards.

Let a person draw a card from the pack, and let him replace it in the parcel from whence it was drawn, by dextrously offering that part. Cut the cards several times, so that a long card may be always at bottom. Divide the cards in this manner into fix heaps, and giving a die to the

person who drew the card, tell him that the point he throws shall indicate the parcel in which is the card he drew; then take up that parcel and show him the card.

You should put the cards in your pocket immediately after performing this Recreation, and have another pack, ready to show, if any one should ask to see the cards.

RECREATION XCVI.

To separate the two colours of a pack of cards by one cut.

THE pack must be prepared in the same manner as in the 83d Recreation; that is, all the cards of one colour must be cut something narrower at one end than the other. You show the cards, and give them to any one that he may shuffle them, then holding them between
your

your hands, one hand being at each extremity, with one motion you separate the hearts and diamonds from the spades and clubs.

This Recreation is easy and pleasant to perform, but should not be repeated; unless you have another pack of cards which you can adroitly substitute in the place of the former, and with them you may separate the pictured cards from the others, they being prepared for that purpose; which will afford a fresh surprize. You may also write on a number of blank cards certain letters or words that form a question, and on others the answer. Several other recreations may likewise be performed by the same method.

R E C R E A T I O N XCVII.

The metamorphosed cards.

IN the middle of a pack place a card that is something wider than the rest which we will suppose to be the knave of spades, under which place the seven of diamonds, and under that the ten of clubs. On the top of the pack put cards similar to these, and others on which are painted different objects, in the manner following:

First card	A bird
2	A seven of diamonds
3	A flower
4	Another seven of diamonds
5	A bird
6	Ten of clubs
7	A flower
8	Another ten of clubs.

Then

Then seven or eight indifferent cards; the knave of spades, which is the wide card; the seven of diamonds; the ten of clubs; and the rest any indifferent cards.

Two persons are then to draw the two cards that are under the wide card, which are the seven of diamonds and the ten of clubs. You then take the pack in your left hand, and open it at the wide card, as you open a book, and tell him who drew the seven of diamonds to place it in that opening. You then blow on the cards, and without closing them you instantly bring the card which is at top, and on which a bird is painted, over that seven of diamonds*. You then bid the person look at his card, and when he has remarked the change, to place it where it was before. Then blow on the cards a second time, and bringing the seven of diamonds,

* To do this dextrously you must wet the middle finger of your left hand, with which you are to bring the card to the middle of the pack.

which

which is at the top of the pack, to the opening, you bid him look at his card again, when he will see it is that he drew. You may do the same with all the other painted cards, either with the same person, or with him who drew the ten of clubs.

The whole artifice in this Recreation consists in bringing the card at the top of the pack to the opening in the middle, by the wet finger, which requires no great practice. You must observe not to let the pack go out of your hands while you are performing this Recreation.

R E C R E A T I O N XCVIII.

The cards in the opera glafs.

PROVIDE an opera glafs about two inches and a half long, the tube of which is to be ivory, and so thin that the light may pass through it. In this tube place a lens of two inches and a quarter focus

focus, so that a card of about three quarters of an inch long may appear of the size of a common card. At the bottom of the tube there is to be a circle of black pasteboard, to which must be fastened a small card with figures on both sides, by two threads of silk, in such manner that by turning the tube either side of the card may be visible.

You then offer two cards in a pack to two persons, which they are to draw, and that are the same as those in the glass. After which you show each of them the card he has drawn, in the glass, by turning it to the proper position.

The better to induce the parties to draw the two cards, place them first on the top of the pack, and then, by making the pafs, bring them to the middle. When you can make the pafs in a dextrous manner, it is preferable, on many occasions, to the long card, which obliges you to change
the

the pack frequently ; for otherwise it would be observed that the same card is always drawn, and doubtless occasions suspicion.

R E C R E A T I O N XCIX.

The magic ring.

MAKE a ring large enough to go on the second or third finger, (pl. XIV. Fig. 9.) in which let there be set a large transparent stone, to the bottom of which must be fixed a small piece of black silk, that may be either drawn aside or expanded by turning the stone round. Under the silk is to be the figure of a small card.

Then make a person draw the same sort of card as that at the bottom of the ring, and tell him to burn it in the candle. Having first shown him the ring, you take part of the burnt card, and reducing it to
pow-

powder, you rub the stone with it, and at the same time turn it artfully about, so that the small card at bottom may come in view.

RECREATION C.

The card in the mirror.

PROVIDE a mirror, either round, as A, (Plate XIV. Figure 10.) or oval, the frame of which must be at least as wide as a card. The glass in the middle must be made to move in the two grooves C D and E F, and so much of the quicksilver must be scraped off at B, as is equal to the size of a common card. You will observe that the glass must likewise be wider than the distance between the frame, by at least the width of a card.

Then paste over the part where the quicksilver is rubbed off, a piece of paste board, on which is a card, that must exactly

actly fit the space, which must at first be placed behind the frame.

This mirror must be placed against a partition, through which is to go two strings, by which an assistant in the adjoining room can easily move the glass in the grooves, and consequently make the card appear or disappear at pleasure*.

Matters being thus prepared, you contrive to make a person draw the same sort of card with that fixed to the mirror, and place it in the middle of the pack: you

* This Recreation may be performed without an assistant, if a table be placed against the partition, and the string from the glass be made to pass through a leg of it, and communicate with a small trigger, which you may easily push down with your foot, and at the same time be wiping the glass with your handkerchief, that the card may appear the more conspicuous. It may also be diversified by having the figure of a head, suppose that of some absent friend, in the place of the card.

then

then make the pass, and bring it to the bottom; you then direct the person to look for his card in the mirror, when the confederate behind the partition is to draw it slowly forward, and it will appear as if placed between the glass and the quicksilver. While the glass is drawing forward you slide off the card from the bottom of the pack, and convey it away.

The card fixed to the mirror may easily be changed each time the experiment is performed. This Recreation may be also made with the print that has a glass before it, and a frame of sufficient width; by making a slit in the frame through which the card is to pass; but the effect will not be so striking as in the mirror.

R E C R E A T I O N C I.

The marvellous vase.

PLACE a vase of wood or pasteboard AB, (Pl. XIV. Fig. 11.) on a bracket L, fixed to the partition M. Let the inside of this vase be divided into five parts, *c, d, e, f, g*; and let the divisions *c* and *d* be wide enough to admit a pack of cards, and those of *e, f, g*, one card only.

Fix a thread of filk at the point H, the other end of which passing down the division *d*, and over the pulley I, runs along the bracket L, and goes out behind the partition M.

Take three cards from a piquet pack, and place one of them in each of the divisions *e, f, g*, making the filk thread or line go under each of them. In the division *c*, put the pack of cards from which
you

you have taken the three cards that are in the other division.

Then take another pack of cards, at the top of which are to be three cards of the same sort with those in the three small divisions, and making the pafs, bring them to the middle of the pack, and let them be drawn by three different persons. Then give them all the cards to shuffle, after which place the pack in the division *d*, and tell the parties they shall see the three cards they drew come, at their command, separately out of the vafe.

An Assistant behind the partition then drawing the line, with a gentle and equal motion, the three cards will gradually rise out of the vafe. Then take the cards out of the division *c*, and show that those three cards are gone from the pack.

The vafe must be placed so high that the inside cannot be seen by the company.

T 2

You

You may perform this Recreation also without an assistant, by fixing a weight to the end of the silk line, which is to be placed on a support, and let down at pleasure, by means of a spring in the partition.

RECREATION CII.

The divinating perspective glass.

LET a small perspective glass be made, that is wide enough at the end where the object-glass is placed, to hold a table similar to the following.

1.131	10..132	19.133
2.231	11..232	20.233
3.331	12..332	21.333
4.121	13..122	22.123
5.221	14..222	23.223
6.321	15..322	24.323
7.111	16..112	25.113
8.211	17..212	26.213
9.311	18..312	27.313

Take

Fig. 1. p. 235.

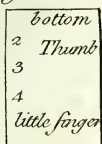


Fig. 2. p. 235.

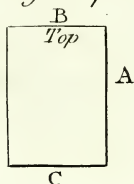


Fig. 3. p. 257.



Fig. 4. p. 257.

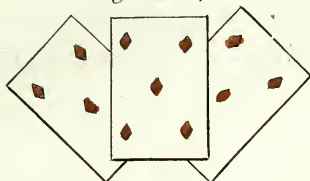


Fig. 5. p. 257.

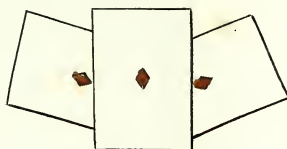


Fig. 6. p. 258.



Fig. 7. p. 258.

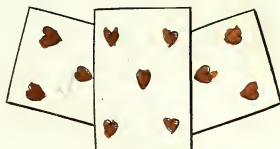


Fig. 8. p. 258.

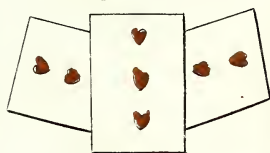


Fig. 9. p. 270.



Fig. 10. p. 271.

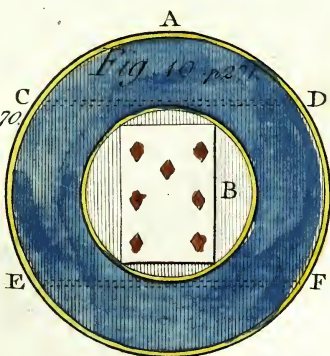
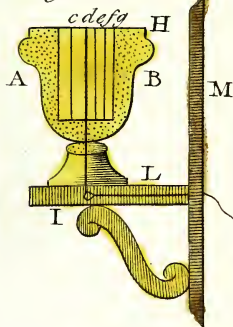


Fig. 11. p. 274.



Take a pack of cards that consists of 27 only, and giving them to a person, desire him to fix on any one, then shuffle them and give the pack to you. Place the twenty-seven cards in three heaps, by laying down one alternately on each heap, but before you lay each card down show it to the person without seeing it yourself; and when the three heaps are finished, ask him at what number, from 1 to 27, he will have his card appear, and in which heap it then is. Then look at the heap through the glass, and if the first of the three numbers which stands against that number it is to appear at be 1, put that heap at top; if the number be 2, put it in the middle; and if it be 3, put it at bottom. Then divide the cards into three heaps, in the same manner, a second and a third time, and his card will then be at the number he chose.

For example. Suppose he desire that his card shall be the 20th from the top, and the first time of making the heaps he

say it is in the third heap; you then look at the table in the perspective, holding it at the same time over that heap, and you see that the first figure is 2, you therefore put that heap in the middle of the pack. The second and third times you in like manner put the heap in which he says it is, at the bottom, the number each time being 3. Then looking at the pack with your glafs, as if to discover which the card was, you lay the cards down one by one, and the twentieth card will be that he fixed on.

You may shew the person his card in the same manner, without asking him at what number it shall appear, by fixing on any number yourself. You may also perform this Recreation with the magnetical dial described in the third volume, by making the hand point to any number, from 1 to 27, at which you intend the card shall be found.

The

The foregoing recreations with the cards will be found sufficient to explain all others of a similar nature, that have or may be made, the number of which is very great. To perform these we have described requires no great practice; the two principal points are, the making the pafs in a dextrous manner, and a certain address by which you influence a person to draw the card you present.

Those recreations that are performed by the long card are, in general, the most easy, but they are confined to a pack of cards that is ready prepared; whereas, those that depend on making the pafs, may be performed with any pack that is offered.

R E C R E A T I O N CIII.

The burnt writing restored.

COVER the outside of a small memorandum-book with black paper, and in one of its inside covers make a flap, to open secretly, and observe there must be nothing over the flap but the black paper that covers the book.

Mix foot with black or brown soap, with which rub the side of the black paper next the flap : then wipe it quite clean, so that a white paper pressed against it will not receive any mark.

Provide a black lead pencil that will not mark without pressing hard on the paper. Have likewise a small box, about the size of the memorandum-book, and that opens on both sides, but on one of them by a private method. Give a person the pencil, and a slip of thin paper, on which he is to write

write what he thinks proper : you present him the memorandum-book at the same time, that he may not write on the bare board. You tell him to keep what he writes to himself, and direct him to burn it on an iron plate laid on a chafingdish of coals, and give you the ashes. You then go into another room to fetch your magic box, before described, and take with you the memorandum-book.

Having previously placed a paper under the flap in the cover of the book, when he presses hard with the pencil, to write on his paper, every stroke, by means of the stuff rubbed on the black paper, will appear on that under the flap. You therefore take it out, and put it into one side of the box.

You then return to the other room, and taking a slip of blank paper, you put it into the other side of the box, strewing the ashes of the burnt paper over it. Then shaking

shaking the box for a few moments, and at the same time turning it dextrously over, you open the other side, and shew the person the paper you first put in, the writing on which he will readily acknowledge to be his.

If there be a press or cupboard that communicates with the next room, as in the 64th Recreation, you need only put the book in the press, and your assistant will open it and put the paper in the box, which you presently after take out, and perform the rest of the recreation as before.

There may likewise be a flap in the other cover of the book, and you may rub the paper against that with red lead. In this case you give the person the choice of writing either with a red or black pencil; and present him the proper side of the book accordingly.

RECRE-

RECREATION CIV.

The opaque box rendered transparent.

MAKE a box of three or four inches long, and two or three wide, and have a sort of perspective glass, the bottom of which is of the same size with the box, and slides out, that you may privately place a paper on it. The sides of this perspective are to be of glass, covered on the inside with fine paper.

Let a person write on a slip of paper, putting your memorandum book under it, as in the last Recreation. Then give him the little box, and let him put what he has wrote into it. In the mean time you put the memorandum-book into the press, where the perspective is already placed. Your assistant then takes the paper out of the book, and puts it at the bottom of the perspective ; which you presently take out of the press, and direct the person

person to put the little box, that contains his paper, under it. You then look in at the top of the perspective; and feigning to see through the top of the box, you read what is wrote on the paper at the bottom of the perspective.

With this perspective-box you may perform another recreation, which is, by having in a bag twelve or more ivory counters, numbered, which you shew to the company, that they may see all the numbers are different. You tell a person to draw any one of them, and keep it close in his hand. You then put the bag in the press, when your assistant examines the counters, and sees which is wanting, and puts another of the same number at the bottom of the perspective, which you then take out; and placing the person's hand close to it, look in at the top, and pretending to see through his hand, you name the number on the counter in it.

RECRE-

R E C R E A T I O N CV.

The transposable pieces.

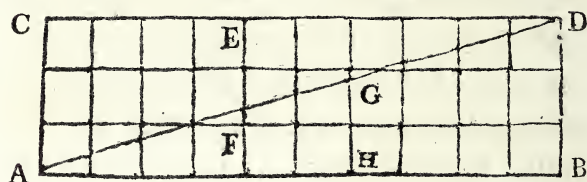
TAKE two guineas and two shillings, and grind part of them away, on one side only, so that they may be but of half the common thickness; and observe that they must be quite thin at the edge; then rivet a guinea and a shilling together. Lay one of these double pieces, with the shilling upwards, on the palm of your hand, at the bottom of your three first fingers; and lay the other piece, with the guinea upward, in like manner, in the other hand. Let the company take notice in which hand is the guinea, and in which the shilling. Then as you shut your hands, you naturally turn the pieces over, and when you open them again, the shilling and the guinea will appear to have changed their places.

R E C R E -

RECREATION CVI.

The geometric money.

DRAW on pasteboard the following rectangle ABCD, whose side AC is three inches, and AB ten inches.

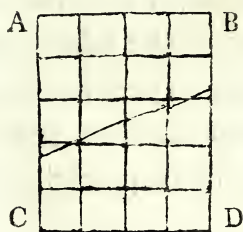


Divide the longest side into ten equal parts, and the shortest into three equal parts, and draw the perpendicular lines, as in the figure, which will divide it into thirty equal squares.

From A to D draw the diagonal AD, and cut the figure, by that line, into two equal triangles, and cut those triangles into two parts, in the direction of the lines EF and GH. You will then have two
 trian-

triangles, and two four-sided irregular figures, which you are to place together, in the manner they stood at first, and in each square you are to draw the figure of a piece of money; observing to make those in the squares, through which the line A D passes, something imperfect.

As the pieces stand together in the foregoing figure, you will count thirty pieces of money only; but if the two triangles and the two irregular figures be joined together, as in the following figures, there will be thirty-two pieces.



RECRE-

R E C R E A T I O N CVII.

The penetrative guinea.

PROVIDE a round tin box, of the size of a large snuff-box, and in this place eight other boxes, which will go easily into each other, and let the least of them be of a size to hold a guinea. Each of these boxes should shut with a hinge, and to the least of them there must be a small lock, that is fastened with a spring, but cannot be opened without a key: and observe that all these boxes must shut so freely, that they may be all closed at once. Place these boxes in each other, with their tops open, in the drawer of the table on which you may make your experiments; or if you please, in your pocket, in such manner that they cannot be displaced.

Then ask a person to lend you a new guinea, and desire him to mark it, that it may not be changed. You take this piece
in

in one hand, and in the other you have another of the same appearance, and putting your hand into the drawer you flip the piece that is marked in the least box, and shutting them all at once, you take them out. Then showing the piece you have in your hand, and which the company suppose to be the same that was marked, you pretend to make it pass through the box and dextrously convey it away.

You then present the box, for the spectators do not yet know there are more than one, to any person in company, who, when he opens it, finds another, and another, till he comes to the last, but that he cannot open without the key, which you then give him, and retiring to a distant part of the room, you tell him to take out the guinea himself, and see if it be that he marked.

This recreation may be made more surprising, by putting the key into the snuff-box of one of the company, which you may do by asking him for a pinch of his

snuff, and at the same time conceal the key, which must be very small, among the snuff : and when the person who is to open the box asks for the key, you tell him that one of the company has it in his snuff-box. This part of the recreation may likewise be performed by means of a confederate.

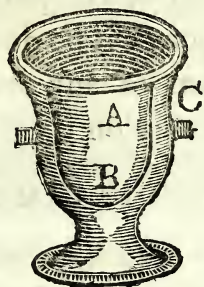
R E C R E A T I O N CVIII.

The resuscitated flower.

PROVIDE a small tin mortar, that is double as A, in the following Fig. whose bottom B turns round on an axis, by means of a spring which communicates with the piece C. There must be a hollow space under the false bottom. To the under side of the bottom fasten, by a thread of fine silk, a flower with its stalk and leaves.

Then take a flower that exactly resembles the other, and plucking it from the stalk, and all the leaves from each other,
put

put them into the mortar, and pound them with a small pestle; after which you show the mortar to the company, that they may see the parts that are all bruised.



Then taking the mortar up in your hands, you hold it over the flame of a lamp or candle, by whose warmth the flower is supposed to be restored; and at the same time pressing the piece at C, the bottom will turn round, the bruised parts descend into the space under the bottom, and the whole flower will be at top; you then put your hand into the mortar, and easily breaking the silk thread, which may be very short as well as fine, you take the flower out and present it to the company.

U 2,

There

There is an experiment fimilar to this, in which a live bird is concealed at the bottom of the mortar, and one that is dead is pounded in it ; after which, by the motion of the bottom, the live-bird is fet at liberty. But furely the pounding a bird in a mortar, though it be dead, muft produce, in perfons of any delicacy, more difguft than recreation.

AN ARTIFICIAL MEMORY.

THE reader muft have obferved, that to perform feveral of the recreations in this book, it is neceffary to have a good memory ; but as that is a gift every one has not from nature, many methods have been contrived to fupply that defect by art ; the moft material of which we fhall here defcribe.

An artificial memory refpects either figures or words : for the former let the five vowels *a, e, i, o, u*, represent the first five digits ; the dipthongs that begin with the first four vowels, as *au, ea, ie, ou*, represent

sent the remaining four digits, and let *y* stand for an o, or cypher. Let the ten first consonants also stand for the nine digits and the cypher; as in the following table.

<i>a</i>	<i>e</i>	<i>i</i>	<i>o</i>	<i>u</i>	<i>au</i>	<i>ea</i>	<i>ie</i>	<i>ou</i>	<i>y</i>
1	2	3	4	5	6	7	8	9	o
<i>b</i>	<i>c</i>	<i>d</i>	<i>f</i>	<i>g</i>	<i>h</i>	<i>k</i>	<i>l</i>	<i>m</i>	<i>n</i>

Then to represent any number let the first letter be a vowel or dipthong, the second a consonant, the third a vowel the fourth a consonant, &c. Thus for the number 1763, you write or remember the word *akaud*. If there are several sums to be retained, you place the words in forms of verses, which will make them more pleasing to repeat and more easy to remember: for example, if you would remember the dates of the accession of the family of Stuart to the crown of England; the powder plot; the decapitation of Charles I. the Restoration; the Revolution; the Union of England and Scotland; the accession of the House of Hanover; and the last rebellion, which were in 1603, 1605, 1649,

U 3 1660,

1660, 1689, 1707, 1714, and 1746, you write as follows, for you are to observe that in this, and in similar cases, where the first figure is always the same, it is unnecessary to write it after the first time.

Ahyd hyg hòm haun
hiem kyk kaf koh.

This method is rendered in some instances still more easy by adding parts of words to dates: thus to remember the date of the accession of the monarchs from James I. to the present king, you may write as follows, omitting the letter that would stand for one thousand.

Jamhyd Charheg Charhom Jamhieg
Willhiem Ankyc Georkaf Seckek Thikaun

When several cyphers come together, instead of repeating *y* or *n*, you may write *y* or *n* 2, 3, &c. Thus for 3400 write *ify*2, and for 256000 write *ehun*3.

To remember any number of words, select the initial letters of those words, and
to

to the first add *a* if it begin with a consonant, or *b* if it begin with a vowel. In like manner add *e* or *c* to the second initial letter ; to the third add *i* or *d* ; to the fourth *o* or *f* ; and to the fifth *u* or *g*. So that of the five initials you make five syllables, which are joined together in one word. Then of the next five initials you make, in the same manner, another word, and of every two words you make a verse. For example, suppose you would remember the names of all the kings since the Conquest, in the order in which they reigned, you then write as follows.

Wawehisohu	Rajehiefeg
Ebrehihohu	Ebecrihohu
Ebmeedjocu	Cajewiafgu Gage

Or if you would remember the letters that begin any number of verses, suppose the twenty-first lines of Pope's Essay on Man, you write as follows.

Abtelitoeg	Abacodtotu
Taoceadflu	Basewioffu.



THE
C O N T E N T S.

P N E U M A T I C S.

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RECREATION I. p. 25

The bottles broke by air.

A bottle is placed over the hole in the plate of the air pump, and the internal air being exhausted the bottle is broke by the weight of the external air. The same effect is produced by the spring of the air in the bottle, when the weight of the external air is taken off. A person's hand, when laid on the mouth of the receiver, is pressed by a great weight.

RECREATION II. p. 27

The brass hemispheres.

These hemispheres being placed close together, and the air exhausted from them, a force equal to one hundred and eighty-seven pounds is required to separate them.

RECRE-

R E C R E A T I O N III. p. 28

Water boiled by air.

A vessel with hot water is placed in the receiver, and the air being exhausted the water boils with great rapidity.

R E C R E A T I O N IV. p. 29

The aerial bubbles.

A piece of stone or iron being put in a vessel of water placed in the receiver, and the air exhausted, a great number of bubbles, resembling drops of dew, rise on the surface of the body in the water.

R E C R E A T I O N V. p. 29

The floating stone.

A piece of cork is tied to a stone that will just sink it, in a vessel of water placed in the

the receiver, and the air is exhausted, when the stone and cork float on the surface of the water.

R E C R E A T I O N VI. p. 30

The withered fruit restored.

A shrivelled apple being placed in the receiver, and the air exhausted, it is plumed up, and looks as fair as when first gathered.

R E C R E A T I O N VII. p. 31

The vegetable air bubbles.

Part of a plant is put in a vessel of water placed in the receiver : when the air is exhausted that in the plant arises from the extremities of all its vessels, and presents a beautiful appearance.

R E C R E-

RECREATION VIII. p. 32

The mercurial rod.

A piece of stick is put in a vessel of mercury, in the receiver, and the air exhausted : when it is let in again it forces the mercury into the stick, which is then several times heavier than before, and when cut the mercury glitters in every part.

RECREATION IX. p. 33

The mystical bell.

A wire that is fastened to a bell in the receiver goes through the top of it ; when the air is exhausted and the bell shook by the wire, no sound is heard ; but as the air is let in again the sound becomes continually more audible.

RECRE-

RECREATION X. p. 33

Feathers heavier than air.

A piece of lead is hung to one end of a balance, and as many feathers to the other end as will keep the balance in equilibrium ; but when it is put in the receiver, and the air exhausted, the feathers will preponderate.

RECREATION XI. p. 35

The self-moving wheel.

A wheel with small vanes is placed in the receiver, and the air exhausted ; when it is let in again, by a small cock, it rushes against the vanes and puts the wheel in motion. If the pump be continually worked, the motion of the wheel will be perpetual, without any apparent mover.

R E C R E -

RECREATION XII. p. 36

The animated figures.

Several perpendicular cylinders are fixed in a circular frame ; in each cylinder is placed the figure of an animal, under which is a piston, and under that a spring ; and at the bottom of the cylinder is a small hole. When this machine is placed in the receiver and the air exhausted, the figures all rise up out of the cylinders ; and when the air is let in again they all retire to their several apartments.

RECREATION XIII. p. 38

The artificial halo.

A candle is placed on one side of a receiver, and a spectator on the other ; as the air is exhausted the light of the candle is refracted into circles of various colours, like those of a halo.

R E C R E -

RECREATION XIV. p. 39

The mercurial shower.

A piece of wood is cemented to the top of the receiver, and mercury poured over it. The pressure of the air, as the receiver is exhausted, forces the mercury through the wood in the form of a shower, that is sometimes luminous in the dark.

RECREATION XV. p. 39

The fountain in vacuo.

A tube that is hermetically sealed at one end, and closed by a stop-cock at the other, is placed on the receiver, and when the air is exhausted from the tube it is immersed in water, which will then play up in the tube, in the form of a fountain.

RECRE-

R E C R E A T I O N XVI. p. 40

The air-gun.

The air-gun consists of two barrels (Plate III. Fig. 1.) and a syringe that condenses the air between the barrels. Near the stock of the gun is a valve and a trigger, by which the air is admitted behind the ball and forces it out. Some air-guns contain several balls, which they discharge successively.

R E C R E A T I O N XVII. p. 42

Artificial rain and hail.

In a hollow cylinder (Pl. III. Fig. 3.) that has five oblique partitions, and a small hole in each of them, is placed a quantity of lead shot, and when the cylinder is turned round, the sound of the shot, in passing through the partitions, resembles that of rain or hail, according to the size of the shot.

RECREATION XVIII. p. 43

The magical flowers and fruit.

The stem of an artificial orange tree, that is hollow, (Pl. III. Fig. 4.) is placed in a copper vessel, in which there is a quantity of condensed air, and when a cock is turned, the air rushing up the tree, forces out the artificial fruit concealed in the end of the branches.

H Y D R O L O G Y.

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R E C R E A T I O N XIX. p. 84

The hydrostatic bellows.

Two circular horizontal boards (Pl. VI. Fig. 5.) are joined by leathers, and in the upper board is fixed a perpendicular brass pipe. If a man standing on the board, blow into the tube, he will raise himself up, or if water be poured in, a large weight will be raised.

R E C R E A T I O N XX. p. 85

The water-clock.

A glass cylinder (Pl. VII. Fig. 1.) has a small hole at the bottom, by which water drops out. On the surface of the

X 2 water

water floats a glass tube, whose neck is confined by the cover of the cylinder, and as it descends shows the hour, by a scale marked on it.

R E C R E A T I O N XXI. p. 88

The globular fountain.

Over the jet of a fountain is placed a pipe, and at the end of that a hollow globe, in which a number of small holes are made: the water of the fountain rushing up the pipe enters the globe, and being forced out of its holes forms a sphere of water.

R E C R E A T I O N XXII. p. 89

The hydraulic dancer.

A small figure of a man (Pl. VII. Fig. 2.) is made of cork, and within it is placed a cone of leaf brass: this figure being placed on the top of a jet will remain suspended, and perform a variety of motions

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motions. A similar experiment is made with a light ball of copper, Fig. 3.

RECREATION XXIII. p. 90

The hemispherical cascade.

To the top of a jet is screwed a pipe that enters the bottom of an inverted cone (Plate VII. Fig. 5.) the water from the pipe falling into the cone runs over it in form of a hemispherical cascade. If this fountain be reversed, it will have the form of a vase, Fig. 6.

RECREATION XXIV. p. 91

The water sun.

Two small portions of a sphere (Pl. VII. Fig. 7.) are joined together, and fixed to a pipe from whence a jet flows: near that part where the portions of the spheres join, are a number of holes; and the water rushing violently into the

X 3 cavity

cavity is forced out of the holes, in the figure of the fun. Several pieces of this sort may be placed over each other, and the same pipe may supply them all, as in Fig. 8.

RECREATION XXV. p. 92

The revolving water-fun.

A number of small tubes are fixed in the side of a hollow circle, (Plate VIII. Fig. 1.) which is placed over a jet, in such manner that it will turn freely round. The water rushing into the hollow circle keeps it in continual motion, and at the same time forcing out of the tubes, forms the figure of a revolving fun.

RECREATION XXVI. p. 93

The phial of the four elements.

Glass, finely powdered, oil of tartar, tincture of salt of tartar, and distilled rock oil,

oil, are put into a phial, and shook together ; after a short time they separate, and each assumes its place, according to its specific gravity : the glass at bottom representing the earth, the oil of tartar the water, the tincture the air, and the rock oil, which mounts to the top, the element of fire.

R E C R E A T I O N XXVII. p. 94

The magic bottle.

A bottle with a very small neck, being filled with wine, and placed in a vessel of water, (Plate VIII. Fig. 2.) the wine will come out of the bottle and float on the surface of the water, which will descend and fill the bottle. A similar effect is produced by filling the bottle with water, and placing it, with the mouth downward, in a vessel of wine.

R E C R E A T I O N XXVIII. p. 96

The compound jet d'eau.

A tube with a very small orifice is inserted in the neck of a copper vessel, (Pl. VIII. Fig. 6.) in which there is a cock. Air is first injected by a syringe, and then water, and the cock is turned. This vessel contains an extempore jet d'eau; for whenever the cock is opened, the water rushes out with great violence.

R E C R E A T I O N XXIX. p. 98

The marvellous vessel.

At the bottom of a tin vessel, that has a narrow mouth, there are a great number of very small holes. This vessel is plunged in water, and corked when it is full, and as long as it remains so no water will come out, but when it is uncorked the water will run out of the
holes

holes at the bottom of the vessel. An experiment on the same principle, by placing a paper over a glass filled with water, then inverting the glass and drawing the paper away ; when the water will remain suspended in the glass.

RECREATION XXX. p. 99

The circulating fountain.

This fountain has two boxes, the uppermost of which is supported by two hollow pillars (Plate VIII. Fig. 5.) And on that box is placed a basin, into which water being poured, it runs down one of the pillars, into the lower box, and driving the air up the other pillar, into the upper box, forces the water up a pipe and forms a fountain. The water falling into the basin, descends by the pillar, in the same manner as before, and making a fresh impulse on the water in the upper basin, by forcing the air up
the

the other pillar, the fountain is kept continually playing, as long as any water remains in the upper box.

RECREATION XXXI. p. 102

The magical cascade.

In a tin vessel, (Plate VIII. Fig. 4.) water is poured, and in the center of it is fixed a pipe; whose upper end is above the water in the vessel: to this pipe are joined four arms, by which it is supported over a basin, at the center of which is a small hole. At the bottom of the vessel are several small tubes, by which the water runs into the basin; but when it rises above the lower end of the pipe in the centre of the vessel, the circulation of the air being stopped, the tubes cease to flow. When so much of the water is run out of the basin as to admit the air to enter the pipe, the tubes flow again: and thus they alternately

nately flow and stop, as long as any water remains in the vessel.

R E C R E A T I O N XXXII. p. 104

The illuminated fountain.

This fountain is formed by two cylindrical vessels that are connected by four pipes, (Plate VIII. Fig. 7.) On the lower vessel is placed a basin, from which goes a tube, that reaches almost to the bottom of the vessel, and by which water is poured into it. To each of the pipes a candlestick is joined, and when the candles are lighted, the air in the pipes being rarified, that in the upper vessel rushes down the pipes, and pressing on the water in the lower vessel, makes it rise out of the tube, in form of a fountain : but when the candles are extinguished, and the circulation of the air stopped, the fountain no longer plays.

R E C R E-

R E C R E A T I O N XXXIII. p. 105

The solar fountain.

A globe of thin copper, half filled with water, is placed on a frame (Plate VIII. Fig. 8.) There is a communication between the lower part of the globe, and a pipe placed in a bason at the bottom of the frame, by one of the legs, which is hollow. Near the pipe in the bason is a cock, by which the communication may be stopped. When the sun shines on the globe the air within it being rarified, presses on the water, and forcing it down the leg of the frame opens a valve at the bottom, and the water rises out of the pipe in the bason, in form of a fountain. At night the cold air pressing on the adjutage shuts the valve, and stops the fountain; and at the same time pressing on the water in the bason, forces it back into the

the

the globe, so as to fill it to the same height as before.

R E C R E A T I O N XXXIV. p. 108

The cup of Tantalus.

In a tall narrow cup (Plate IX. Fig. 1.) is placed an image, in which is concealed a syphon, that beginning at one foot rises to the upper part of the breast, and from thence descending through the other foot, on which the image stands, goes out at the bottom of the cup. Therefore, when the liquor poured into this cup rises to the chin of the image, it begins to run out.

R E C R E A T I O N XXXV. p. 110

The sea gage.

This instrument consists of a hollow globe,
(Plate IX. Fig. 2, and 3,) to which is
fixed

fixed a tube, that is immersed in a vessel of mercury, on which floats a surface of treacle ; and to the bottom is hung a weight, sufficient to sink the whole machine. While this instrument is sinking the water will force the mercury and treacle up the tube, according to the depth it has descended, and the mark of the treacle on the tube shows to what height it has been forced. When the machine comes to the bottom, the weight striking against the ground is disengaged, by means of a catch and a spring, and the other parts of the machine rise to the surface of the water. By the addition of the ball and tube, Fig. 3, the sea may be sounded to the depth of 13200 feet, that is, two miles and a half, p. 114.

RECREATION XXXVI. p. 115

The diving bell.

This machine is in form of a bell, (Plate IX. Fig. 4.) and is coated with lead. In the top is fixed a glass, to let in the light and a cock to let out the foul air. Near the bottom is a circular seat for the divers to sit on. This bell is supplied with air by two barrels, that are let down and drawn up alternately : and it is so light in fair weather, that the divers can see to read distinctly. This machine is let down from the ship by a sprit fastened to the mast-head. There is a contrivance to dispatch a diver to the distance of a hundred yards, p. 120. Construction of a different machine for a single person, Fig. 5. p. 123.

P Y R O-

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The effects of fire on other bodies, aph.

4 to 9.—Other properties of fire, aph.

10 to 12.

RECREATION XXXVII. p. 133

The inflammable phosphorus.

The meal of any vegetable is put into an iron pan, where it is heated till it becomes a black powder. To one part of this powder are added four parts of alum, and the whole put into a phial, and placed in a sand heat, and gradually raised till the glass and matter is red hot; the neck of the phial is then closed with wax. A small quantity of this powder being shook out, immediately takes fire and burns. This phosphorus will
retain

retain its virtue, if it be kept from the air, for three months.

RECREATION XXXVIII. p. 136

The liquid phosphorus.

A small piece of common phosphorus is boiled in water, and the mixture is put in a phial, which is sealed up. This mixture shines in the dark for several months, when the phial is shook. Pleasing recreations to be made with this phosphorus, p. 137.

RECREATION XXXIX. p. 137

The fulminating gold.

To a dissolution of gold in aqua regia common water is added, and to that mixture, the spirit of sal ammoniac: the gold that precipitates is taken out and dried. A grain of this powder put in a spoon, over a candle, will go off with a loud report.

R E C R E A T I O N XL. p. 138

The burning fountain.

An eolipile, containing spirits of wine, is placed in a vessel of boiling water, (Plate X. Fig. 11.) To the eolipile is joined a pipe whose orifice is extremely small. The spirit is forced out of the eolipile by the heat of the water, and when a candle is brought near the vessel, the spirit takes fire, and continues to burn, for some time. This phenomenon improved by fisting over it the filings of iron, p. 140.

R E C R E A T I O N XLI. p. 140

Prince Rupert's drop.

A small quantity of melted glass is dropped into water, where it assumes the form of a drop, with a small tail ; and when that tail is broke the whole drop bursts with

with violence into a fine powder. Con-
jecture on the cause of this phenome-
non, p. 141.

R E C R E A T I O N XLII. p. 142.

The revived rose.

A faded rose is held over the fumes of sul-
phur, when it becomes quite white : it
is then dipped in water, and after five
or six hours it becomes quite red.

R E C R E A T I O N XLIII. p. 143

Writing on glass by the rays of the sun.

In a glass decanter, well stopped, that
contains a dissolution of chalk in aqua
fortis, is put a dissolution of silver.
On the decanter is pasted a paper, from
which letters are cut out, and when it
is set in the sun the parts on the glass
that form the letters turn black.

RECREATION XLIV. p. 144

The magic picture.

Between two pieces of glass placed at one-twentieth of an inch from each other, a distillation of hog's lard and white wax is poured. A coloured print is pasted with its face to one of the glasses, and the whole is put in a frame. When the mixture is cold the print is invisible, but when the glasses are heated the print appears as if there was only one glass before it.

RECREATION XLV. p. 146

The luminous oracle.

In the front of an upright tin box, (Pl. XII. Fig. 1.) is a small square hole, and in the back is a door by which candles are put in. In the two sides are grooves, in which slide a double glass prepared
as

as in the last recreation : behind this glass is pasted a black paper, from which letters are cut out, that answer questions wrote on cards. When a part of the glass that contains a particular answer is drawn up, before the hole, the heat of the candles makes the letters become visible.

R E C R E A T I O N XLVI. p. 149

To produce the appearance of a flower from its ashes.

In the front of a tin box, (Pl. XII. Fig. 4) is a glass; behind it is a small tin tube, in which a flower is placed, and behind that a double glass, prepared as in the 44th Recreation. You present a flower, similar to that in the tube, to a person, which he throws on a chafingdish of hot coals; you then place the chafingdish under the box, and the heat makes the flower in the tube gradually visible.

RECREATION XLVII. p. 151

To produce fire by the mixture of two cold liquors.

An equal quantity of the distilled oil of cloves or turpentine, and of Glauber's spirit of nitre, made as here described, are put together in a glass vessel, and the mixture immediately takes fire and burns away.

RECREATION XLVIII. p. 152

Artificial lightning.

Powder of resin is put in a tin tube that has holes on one side, by which the powder is shook over the flame of a torch, when it produces a coruscation that strongly resembles lightning.

RECRE-

R E C R E A T I O N XLIX. p. 153

Artificial thunder.

An ounce of oil of vitriol and two drams of iron filings are shook in a strong bottle, and when a lighted candle is brought near the mouth of the bottle, an inflammation and a loud noise presently ensue. A similar explosion produced by putting a certain quantity of the mixture of three parts of nitre, two of salt of tartar, and two of sulphur, in an iron shovel over a coal fire.

R E C R E A T I O N L. p. 155

The predicted earthquake and volcano.

Equal quantities of iron filings and sulphur are ground together : about fifty pounds of this powder is wrought up with water into a stiff paste, and buried a foot under the earth. In about eight

Y 4

hours

hours the ground will have, emit sulphureous steams, and at last, bursting into flames, form a true volcano.

RECREATION LI. p. 158

To imitate a jet de feu, column, globe, or pyramid of fire.

In a black or deep blue paper are made a number of cuts with the end of a pen-knife, and holes with a piercer, that all run in straight lines, as in plate X. Fig. 1, and 2 : behind the paper is placed a strong light, by which the figures appear as bright illuminations. To give these pieces motion, they must be placed on a wheel of thin wire, adapted to their figures, as that of Fig. 7, to the pieces 5 and 6 ; to these wheels any degree of velocity may be given. To represent pieces that flow from the circumference to the center, and at the same time others that flow from the center to the circumference, as in Fig. 9, a double spiral wheel,

wheel, as Fig. 10, must be placed behind the other. When these pieces are of a small size, they should be placed in a box, that no light may appear, but what comes through the paper.

R E C R E A T I O N LII. p. 166

To represent cascades of fire.

The paper to represent a cascade is wound upon a roller, as Plate XI. Fig. 3, and as the handle is turned, and the paper gradually descends, it represents a cascade of fire. A cascade may be also represented by a spiral, as in Fig. 4.

R E C R E A T I O N LIII. p. 169

Imitative illuminations.

These illuminations differ from the preceding, in having figures of architecture, &c. drawn on the four part of the paper, and those parts only where the lamps are to appear, cut, or pierced.

They

They are placed in a box, with a very strong light behind; and a faint light before them, to make the drawing on the front of the paper visible. The light of all these illuminations should be of different colours, according to the pieces they are to represent, and which is to be effected by pasting a very thin paper, tinged with a particular colour, over the parts cut out.

A P P E N D I X.

RECREATION LIV. p. 175

Chymical transcolourations.

Antimony and mercury, by different preparations, produce almost all the colours of nature. A gold colour is made by mixing a limpid liquor with a grey powder, and then changed to the colour of milk by being poured into a clean glass, p. 176. An almost limpid liquor turned blue, and made pellucid

lucid. Method of producing various blues and greens, p. 177.

RECREATION LV. p. 178

A colourless liquor is made black, by pouring it into a clean glass.

An infusion of white galls is poured into a glass dipped into a solution of vitriol.

RECREATION LVI. p. 178

A pellucid liquor is turned black, by adding to it a white powder.

The same done by a pellucid drop, or by the addition of yellow or red powder, or by a drop of gold coloured liquor, p. 179.—Method of making any of these black liquors pellucid again, p. 180, and then again black, &c.

R E C R E -

R E C R E A T I O N LVII. p. 181

Different colours are produced by pouring a limpid liquor into a clean glass.

A solution of mercury or silver, in spirit of nitre, is poured into a glass dipped in spirit of sea salt.

R E C R E A T I O N LVIII. p. 182

The colour that appears and disappears by the influence of the air.

A blue tincture made of copper filing dissolved in volatile spirit, disappears when the bottle is stopped, but when it is unstopped, the colour presently returns.

S Y M P A T H E T I C I N K S. p. 183

These inks are of five sorts; the first of which are those that are invisible till exposed to the fumes of another liquor.

Dis-

Different methods of making these inks, p. 184. Method of preparing the vivifying liquor to make this ink apparent.

R E C R E A T I O N LIX. p. 189

The book of fate.

On seventy or eighty papers questions are wrote, and under them answers in these sympathetic inks. Several of these papers are chose by different persons, who put them in a book that has the same number of leaves, and on which the same questions are wrote. In the cover of this book is concealed a double paper, dipped in the vivifying liquor, and the book is closed ; when the vapour of the liquor, penetrating the leaves, makes the answers on the papers become visible.

R E-

RECREATION LX. p. 191

The marvellous portrait.

At the bottom of a box (Plate XII Fig. 5) is placed a paper dipped in the vivifying liquor, and over it is put a pasteboard. Several papers on which figures are drawn with the sympathetic ink, are given to a person, and he making choice of one of them, you tell him it shall show him the portrait, and present the employment of an absent friend : then putting the paper in the box, and pressing it down by a board over it, after a few moments you take it out, and shew him a figure in the employment you intended.

RECREATION LXI. p. 193

The artificial hand.

A hand and arm of wood, constructed mechanically, are placed on a pedestal, covered

vered with green cloth (Pl. XII. Fig. 6) Between the thumb and fore-fingers, which are moveable, is placed a pen, and under that part of the cloth is put a paper dipped in the vivifying liquor. Several cards, on which questions are wrote, are given to a person, and he choosíng one of them, you place a paper, on which the answer is wrote in the sympathyetic ink, under the pen, and giving the arm a motion, by means of an assistant in an adjoining room, to the partition of which the arm joins, by the time the pen has passed over the paper the answer will be visible.

Sympathetic inks of the second class, which are those that become visible by being exposed to the air. Inks of this kind made by the dissolution of silver and other metals, p. 197.

R E C R E-

R E C R E A T I O N LXII. p. 198

The writing against the wall.

A question is wrote with common ink, and under it the answer in this sympathetic ink. This paper being placed against a wall, the answer will be visible after twenty-four hours.

R E C R E A T I O N LXIII. p. 199

The talisman.

This talisman consists of a triangular metal box, (Plate XII. Fig. 7.) in the top of which is concealed a heated plate of iron. A paper on which a question is wrote in common ink, and an answer in that sort of sympathetic ink which does not appear till it is heated, is put in the box, and after a few moments the answer appears ; each word of which is of a different colour.

R E C R E-

RECREATION LXIV. p. 202

The sibyls.

On the top of a hollow pedestal (Plate XIII. Fig. 1.) is a dial, that has nineteen divisions, in twelve of which are drawn the signs of the zodiac, and on the others the seven planets. To this dial is fixed an index, that is moved by a pulley underneath : this pulley communicates with two rollers in a box at the end of the pedestal, and on these rollers are wound a paper, on which is wrote the names of the seven sibyls, one of which appears at an opening in the front of the box. On seven cards questions are wrote, and the signs of the planets drawn, and on the seven leaves of a book are wrote, in the sympathetic ink that does not appear till heated, the names of the sibyls, and in each leaf, on pieces of paper, different answers

to each question on the cards. A person chooses one of the cards, and conceals the rest ; then sets the index to the same planet on the circle as on his card, and covers the circle. He next opens the door in the front of the box, and tells you the name of the sibyl. You then take out the papers in that leaf of your book where the name of that sibyl is wrote, and the person choosing one of them, puts it into the talisman, and in a few moments it shows the answer.

RECREATION LXV. p. 207

The magic urn.

You draw on a paper the figure of a flower, with that ink which resembles it in colour, and does not appear till heated. You then burn a flower of that sort on a chafing-dish of coals, and strewing some of the ashes over the paper, you put it in an urn, (Plate XIII. Fig. 5.) in which

which a small heated cylinder is concealed, and taking it out presently after, you show the figure of the flower on the paper.

Methods of making yellow, red, green, and violent sympathetic inks of the second class that is, such as are not visible, till another liquor is passed lightly over them, p. 209.—Preparation of the liquor to make these inks visible, p. 211.

R E C R E A T I O N LXVI. p. 212

The revived bouquets.

A bouquet is made of artificial flowers. each of which is put in one of these sympathetic inks. The bouquet is then dipped in the vivifying liquor, when each of the flowers presently appear of its natural colour.

RECREATION LXVII. p. 213

The transcoloured writing.

You write several words on a paper with the violet ink, and ask a person whether he will have them appear yellow green or red. You then take a sponge that has three distinct sides, each of which is wetted with one of those three sympathetic inks, and draw one of the sides of the sponge over the writing, according to the colour required.

Sympathetic inks of the third class, that is, such as become visible by having a fine powder strewn over them, p. 214,

RECREATION LXVIII. p. 214

Magical vegetation.

A leaf or flower being drawn with this ink, you burn a similar leaf or flower, and
strew

strew its ashes on the drawing, when the figure becomes immediately visible.

Sympathetic inks of the fourth class, which are such as become visible by being exposed to the fire, p. 215.

RECREATION LXIX. p. 216

The transmutable cards.

Over an ace of hearts draw, with this sympathetic ink, a spade and four other spades on each side of it. Let a person draw this card, and another person the nine of spades, and let the last person burn his card. You give the ashes to him who drew the heart, that he may put them with that card, in a metal box, over a chafingdish, for a short time and when he takes it out, he finds it turned to the nine of spades.

RECREATION LXX. p. 217

The convertible cards.

You write on a card the word *law*, with this ink, and hold it before the fire till it is visible. You then add to and alter the letters of that word, with this ink, so as to make it *old woman*, and leave the alteration invisible. A person draws this card and writes his name on it, which you hold to the fire to dry, when the alteration you made becomes visible.

RECREATION LXXI. p. 219

The oracular letters.

Several questions are wrote on different papers, in this ink, and held before the fire. The answers are wrote and left invisible. These papers are folded up in form of letters, with the answers under

der the part where they are sealed, and the heat of the wax makes them visible. A similar experiment with a card enclosed in a letter

Method of making the sympathetic ink of the fifth class, which does not appear till heated, and disappears when cold, p. 221.

R E C R E A T I O N LXXII. p. 222

The incomprehensible writing.

The names of two cards are wrote with this ink, at the two ends of a paper, (Pl. XIII. Fig. 6.) Two persons draw the same cards privately, and you propose to make the names of those cards appear on the paper, without knowing what they are. You then put the paper in a metal box, Fig. 4, under one end of whose cover is a heated plate of metal, and the names become alternately visible.

RECREATION LXXIII. p. 252

Winter changed to spring.

In a print that represents winter, the trees, plants, &c. are traced over with this ink, and when the print is set in the sun they become perfectly green. If it be placed again in the cold, winter again appears : and thus the two seasons may be changed, alternately, a great number of times.

Methods of making sympathetic inks, that appear by being wetted with water, p. 226.

RECREATION LXXIV. p. 228

The oracular mirror.

A mirror is moveable in a frame ; (Plate XIII. Fig. 7.) on one side of this mirror is wrote with Spanish chalk, the word
yes ;

yes; on the other side is wrote *no*: these words are wiped off, but when breathed on become visible. A person asking a question, you put your mouth to the mirror, as if to whisper to it, and the word *yes* or *no* appears immediately.

R E C R E A T I O N LXXV. p. 230

The tree of Diana.

This tree is made by a globule of the amalgam of silver with mercury, put in a dissolution of silver filings and mercury in aqua fortis. From this globule arise branches, that, by spreading, form a shrub or bushy tree, of a silver hue. Another method of producing this tree, p. 231.

R E C R E-

RECREATIONS OF ADDRESS AND
DEXTERITY.

Recreations with the cards—Method of
making the pafs, p. 235.

RECREATION LXXVI. p. 237

The card of divination.

You make feveral perfons, who do not
ftand very near each other, draw the
long card ; and each perfon fhuffles the
pack. You then lay down feveral cards,
among which is the long card, and ask
each perfon if he fee his card. You
fhuffle the pack, and cutting at the
long card, go up to one of the parties,
and fhew him his card ; and repeat the
fame operation for all the others. Me-
thod of performing this Recreation by
making the pafs, p. 239.

RECREATION LXXVII. p. 240

The four confederate cards.

You fhew a perfon four cards that he may
think on one of them : then dextroufly
place

place two of them at top and two at bottom. You take several cards from the bottom, and ask the person if his card be among them : if not you pass the two cards from the top to the bottom, and show one of them ; and if that be not his card, you bid him draw it from the bottom. If his card be among those you first drew, you separate them dextrously from the rest, place them at the bottom, and then do as before directed.

RECREATION LXXVIII. p. 241.

The numerical card.

The sixteenth card, in a piquet pack, is a long card. You take several from the top, and a person thinks of one of them. You make the pass, and he telling you what number from the top his card was at, you count from that number to 16, and draw aside the 17th, which is the card. You then ask how many more you shall draw before the card appear, which

which being done you throw down the card.

RECREATION LXXIX. p. 242

Divination by the sword.

Place a card drawn under the long card, and then bring it to the top. Throw the pack on the ground, and observe where the top card falls. A handkerchief being bound over your eyes, in such manner that you can see the ground, you touch several cards with a sword, and at last fix it in the top card.

RECREATION LXXX. p. 243.

The cards thought on per force.

Several cards are spread before a person, in such manner that only one is completely visible, and you observe, carefully, whether the person fix his eye on that card: if not, you make him draw

draw a card, and perform some other Recreation.

RECREATION LXXXI. p. 244

The transmutable cards.

There are two cards of the same sort, one of which is put at top, and the other next the bottom card. You show a person the bottom card, and convey it dextrously away ; then drawing off the supposed bottom card, you direct the person to put it under his hand. You next shuffle the pack, and bringing the top card to the bottom, you show it to another person, and convey it privately away ; then drawing off the next card you direct the last person to put it under his hand, and command the cards under the two persons hands to change places, which they will appear to do.

R E C R E -

RECREATION LXXXII. p. 246

The three magical parties.

A person draws the long card, and puts it in any part of the pack. You make the pafs, and bring it to the top: then divide the pack into three heaps, and ask him in which heap his card fhall be, and at what number it fhall appear. You place the heap he names over that at the top where the card is, and after telling down the number of cards named, you make the pafs, bring the card to the top, and turn it up.

RECREATION LXXXIII. p. 247

The inverted cards.

One end of all the cards of a pack are cut a fmaller narrower than the other. A person draws a card, and when he puts it in again you offer the other
end

end of the pack : the cards are then shuffled, and as you turn them up, one by one, you distinguish, by the touch, the card he drew.

RECREATION LXXXIV. p. 249

The card discovered by the touch or smell.

A person draws the long card, puts it in again, and shuffles the cards. You pretend to feel the figures on the cards, or smell to them, and when you come to the long card you turn it up.

RECREATION LXXXV. p. 250

The incomprehensible transposition.

A card of the same sort as the long card is put in an egg : you make a person draw the long card, and while he is breaking the egg, you conceal that card. This Recreation diversified by offering several eggs that each contain the same card ;
and

and by a confederate, who knows the egg in which the card is put.

RECREATION LXXXVI. p. 251

The card in the pocket-book.

This is performed by the aid of a confederate, who knows the card you have taken from the pack, and concealed in your pocket-book.

RECREATION LXXXVII. p. 252

To tell the card that a person has only once touched with his finger.

You agree with your confederate on certain signs, by which to express the suit and particular card ; and you fix on a person to touch the card who stands near your confederate.

RECRE-

RECREATION LXXXVIII. p. 254

To name several cards that two persons have drawn from the pack.

You divide a piquet pack into two parts by a long card, and so dispose the cards of each part that you can easily recollect them. You let a person draw two or more cards from the first part, and put them into the second; and in like manner, another person draws from the second part and puts them into the first, and by spreading the cards on the table, you easily distinguish which cards were drawn.

RECREATION LXXXIX. p. 255

The two convertible cards.

On the ace of spades a heart is slightly pasted, and on the ace of hearts a spade. You lay these two cards on the ground, at the same time flipping off the figures

VOL. IV. A a pasted

pasted on them, and desire two persons to put each of them his foot on one of the cards, and you then command the two cards to change places; which they appear to do. Method of performing a similar experiment with a single card.
p. 256.

RECREATION XC. p. 257

The fifteen thousand livres.

You take two cards like Pl. XIV. Fig. 3. with an ace and five of diamonds; and by placing these cards in different positions, you make them appear to be either 3 or 15.

RECREATION XCI. p. 259

The card discovered under the handkerchief.

A person draws a card and puts it in the middle of the pack: you make the pass, and bring it to the top. Then throw-
ing

ing a handkerchief over the pack, you take off the top card, seeming at the same time to search among the cards.

RECREATION XCII. p. 260

To change the cards that several persons have drawn from the pack.

You make the pass, bring the top card to the middle, and let a person draw it : then make the pass again, and bring it to the middle, and let a second person draw it ; and so for three or four more. You after show the card to the several parties, separately, and they all acknowledge it to be the card they drew.

RECREATION XCIII. p. 261

The four inseparable kings.

The four kings and two other cards are put at the botton : one of the kings is

A a 2 drawn

drawn and put at the top ; then the two other cards are drawn and put in different parts, and when the cards are cut all the kings will be together in the middle.

R E C R E A T I O N XCIV. p. 262

To tell the number of cards by their weight.

There are two long cards, whose number from the top you know, and by cutting at these cards you tell the number over them.

R E C R E A T I O N XCV. p. 263

To discover the card that is drawn by the throw of a die.

The pack consists of only six sorts of cards repeated six times, and at the bottom of each parcel is a long card. A person draws one of these cards and puts it into the same parcel again. You cut the
pack,

pack, by the long cards, into fix heaps, and giving the person a die, tell him his card shall be in that heap which answers to the number he throws on the die.

R E C R E A T I O N XCVI. p. 264

To separate the two colours of a pack of cards by one cut.

The cards are prepared by cutting those of one colour something narrower than the others, as in a former Recreation, and then you separate the two colours by one motion of your hands.

R E C R E A T I O N XCVII. p. 266

The metamorphosed cards.

Under a wide card in the middle of the pack is placed two particular cards, and two others of the same sort at the top : and between them two cards on which figures are painted. You open the pack

A a 3 at

at the wide card, and let a person draw draw one of the two cards and replace it : you then dextrously bring one of the painted cards at top to the middle, and shew him the change : you perform in the like manner with another person and the two other cards.

RECREATION XCVIII. p. 268

The cards in the opera glass.

At the end of an opera-glass is a small card, but which appears there of the common size : this card has figures on both sides, either of which is visible by turning the glass differently. You make a person draw one of those cards from the pack, and then shew it him in the glass.

RECREATION XCIX. p. 270

The magic ring.

Under a large transparent stone in a ring (Plate XIV. Fig. 9.) is the figure of a
small

small card and over it a piece of silk that may be drawn aside, by turning the stone round. A person draws a similar card from the pack, and burns it. You rub the stone with the ashes, and turning it about, show the person the card he burnt.

R E C R E A T I O N C. p. 271

The card in the mirror.

A mirror is moveable in its frame, which is of the width of a card (Pl. XIV. Fig. 10.) A part of the quicksilver is scraped off the mirror, and a card fixed over that part, which is to be behind the frame. This mirror moves in a groove, and there are two strings that go from the back of it, through the partition of the room. You make a person draw the same sort of card as that in the mirror, and put it in the middle of the pack: You make the pass, and bring it to the bottom; then tell him to look in the mir-

ror for his card, and while the confederate is bringing it forward you secrete the card he drew.

RECREATION CI. p. 274

The marvellous vase.

A vase that is placed on a bracket (Plate XIV. Fig. 11.) has five divisions, in three of which a single card is placed, and in another a pack of cards. There is a string that goes through the three small divisions down the bracket, and through the partition. Three persons draw from a pack three cards of the same sort with those in the vase, and putting them in again, shuffle the pack, which you put in the fifth division. Your assistant then makes the three cards rise gently out of the vase, by drawing the string. You take out the other pack, that you had previously placed in the fourth division, and show that the three cards are gone from it.

R E C R E -

R E C R E A T I O N CII. p. 276

The divinating perspective glafs.

A small table of numbers is placed at the end of a perspective glafs. You give a person a pack of twenty-seven cards, that he may think on one of them. You then lay the cards down, singly, in three heaps ; ask the person in which heap his card is ; and at what number it shall appear. Then look at that heap thro' the glafs, and according to the number that stands in the perspective against that he mentioned, you put that heap either at top, in the middle, or at bottom : this operation you perform three times, and then telling the cards down, one by one, the card he fixed on will be at the number he named.

RECREATION CIII. p. 280

The burnt writing restored.

The inside of the cover of a memorandum-book is rubbed over with foot mixed with brown soap ; under this cover you place a piece of paper, and give a person another paper, which he lays on the outside of the book, and writes what he thinks proper, with a pencil you give him, and that will not mark without pressing hard on it : therefore as he writes on the cover, the same letters will be impressed on the paper under it. You direct the person to burn what he has wrote, without showing it : and going into another room to fetch a box, you take the paper from the memorandum-book, and put it in one side of the box. You return to the room, put a blank paper in the other side of the box, and presently after turning it dextrously over, you take out the paper

per on which the impresson is made, which the person will acknowledge to be his writing.

RECREATION CIV. p. 283.

The opaque box rendered transparent.

A person writes what he thinks proper on a slip of paper, the memorandum-book described in the last Recreation being placed under it, and puts the paper in a box, which he keeps. You put the memorandum-book in the press, mentioned in the 64th Recreation, and your confederate takes it out, and puts it at the bottom of a perspective, which you take out, and holding it over the box, see what is wrote on the paper, pretending at the same time to see through the top of the box. A similar experiment with a counter that is taken out of a bag, and another counter of the same sort put at the bottom of a perspective, p. 284.

R E C R E-

RECREATION CV. p. 285

The transposable pieces.

Two guineas and two shillings are ground to half their common thickness, and then one of each sort joined together. One of these double pieces is placed in one hand, with the guinea upward, and the other in the other hand with the shilling upward: then by closing your hands you turn the pieces over, when the shilling and guinea appear to have changed places.

RECREATION CVI. p. 286

The geometric money.

A piece of pasteboard, in form of a parallelogram, (see the Fig. p. 286.) is divided into thirty equal parts, in each of which is drawn the figure of a piece of money. This parallelogram is cut into four parts, and those parts, when formed

formed into two figures, as in p. 287, contain the figures of thirty-two pieces of money.

RECREATION CVI. p. 288

The penetrative guinea.

In a tin box, of the size of a snuff-box, there are eight more, which go into each other ; they all shut with a hinge and the last is locked. These boxes are placed in a drawer, and open. You desire a person to lend you a new guinea, and mark it : this guinea you slip into the least box and close them all at once in taking them out of the drawer ; then having another new guinea in your other hand, and which is supposed to be the same, you pretend to make it pass through the box, and convey it away. You then give the boxes to any one, and he opens them all to the last, of which you give him the key, and on opening that box he finds the guinea he had

had

had marked. This Recreation improved by flipping the key into a stranger's snuff-box, or by a confederate, p. 290.

RECREATION CVIII. p. 290

The resuscitated flower.

There is a double tin mortar, and between its two bottoms in a vacuity (see the Fig. p. 291.) At the side of this mortar is a spring, by which the bottom is turned round. Having placed a flower between the two bottoms, you take another of the same sort, and pulling it to pieces, pound it in a mortar, which you then hold over a lamp, that the flower may be restored; and at the same time pressing the spring with your finger, the bruised parts descend and the whole flower turns up, which you take out and present to the company.

A N A R T I F I C I A L M E M O R Y.

Methods of remembering numbers or dates by the vowels and consonants, p. 293.—Words are to be remembered by joining their initials to vowels and consonants, and forming those combinations into verses, p. 294.

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